G 45, 47, 48, 49, 50.-53
TR - 366 - 373

Tropical Products Institute

G45

Lime juice and lime oil production and markets

Tropical Products Institute Report

G45

Lime juice and lime oil production and markets

J. L. Allen

bruary 1970

Tropical Products Institute, 56/62 Gray's Inn Road, London, W C 1.

Ministry of Overseas Development

Requests for further information should be addressed to:

The Director,
Tropical Products Institute,
56/62 Gray's Inn Road,
London, W.C.1.

Contents

Page

Appendix Tables:

Diagrams

Summary

Lime juice and lime oil are obtained from the fruit of *Citrus aurentifolia* Swingle which has two distinct groups, the acid limes and the sweet limes, but commercial production to-day of lime juice and lime oil comes from the acid varieties of the fruit, two of which are the most important: one is the Mexican or West Indian or Key variety, the other is the Tahitian, Persian or seedless lime. This report examines the limes industry in the main areas of commercial production, namely, the Caribbean, Mexico, the United States and Ghana; reference is also made to developments in the Gambia and Tanzania. Lime juice is a beverage whereas oil of lime is used in perfumes, toilet water, cosmetics, and soaps and as a flavouring in food products, confectionery and beverages.

Dominica

Although production of limes in Dominica is small compared with that of many other producers, the crop is of economic importance to the island and, in 1963, lime juice and oil of lime together accounted for almost 14 per cent of Dominican domestic exports.

The bulk of the lime crop is disposed of to local processors of which there are eight on the island but only two undertake the full treatment of settling, clarification and casking. These two are L. Rose & Co. Ltd., and Messrs. A.C. Shillingford & Co. Rose's operate the only concentration plant on the island.

Dominica's total juice settling capacity is 250,000 gallons of which L. Rose & Co. Ltd. own 130,000 gallons capacity and Shillingford's 46,000.

Oil from Dominica is obtained in two ways: écuelling and distillation. Only a small amount is produced by the former method and yields are low, some 2½ to 3 ozs. of oil per 160 lb. barrel of fruit. The distillation method is the one mostly used and oil obtained in this way from picked fresh limes can give an average of 8 ozs. of oil per barrel compared with the 5½ to 6 ozs. obtained from the pulp of fallen ripe limes after juice extraction and racking.

The largest markets for lime juice are the United Kingdom, USA and Canada. The United Kingdom is the principal market for Dominican lime oil.

Jamaica

Although production of limes in Jamaica is greater than that in Dominica, its importance to the economy of the island is not so significant and the fruit is grown mainly as a pasture crop on grazing land or is interplanted between coconut trees.

Exports of lime juice and lime oil go almost entirely to the United Kingdom and both quantities exported and unit prices have shown a tendency to increase in

Grenada

Grenada is a small producer of lime juice and exports have tailed off considerably in recent years, and in 1963 hurricane damage badly affected the crop. Such lime juice as is exported goes mainly to the territories of Dominica and Trinidad.

Exports of lime oil, on the other hand, increased in the three years up to 1965, probably because higher world prices made it worthwhile for the Grenadian growers to process the limes.

Guyana

The bulk of Guyana's lime juice exports are of the settled type and shipments are made mainly to the United Kingdom market. Most of the lime oil produced is distilled and is produced for export, mainly to the United Kingdom. Some écuelled oil is produced which is used almost exclusively in a local product; any écuelled oil produced in excess of local demand is exported.

Trinidad and Tobago

The limes are grown among other crops, mainly by small-holders who look to the fruit to provide them with another cash crop. Thus the economic importance of limes in these islands, compared with other citrus, is relatively small. Prices paid to growers have varied considerably and, sometimes, have been so low as to make it uneconomical for growers to collect the fruit. However, the present outlook is more encouraging and the local growers have been planting additional trees, which will mean some additional fruit in a few years time.

The only processing plant crushes an average of 3 million pounds of fruit annually with an approximate yield of 93,000 gallons of settled juice and 10,000 lbs. of distilled oil. No concentrated juice is produced.

The United Kingdom is the best market for the juice, followed by the USA and Canada.

An insignificant amount of écuelled oil is exported, but the bulk of sales is of distilled oil, Canada and the United Kingdom being usually the larger markets, although Bermuda has also appeared as a large but irregular buyer.

Montserrat, St. Lucia, St. Vincent

Montserrat exports juice to the United Kingdom and Canada but does not export oil. The small production of juice on St. Lucia has declined and no export trade is recorded after 1961. St. Vincent has exported insignificant quantities of écuelled oil but there is the possible private development in the future of some 500 acres of land for lime production.

Haiti and Cuba

No lime juice appears to be produced in Haiti and most of the oil produced is probably exported to USA whose imports from Haiti have shown a tendency to increase. Cuba had a small but growing share of the lime oil market in the USA up to 1960 since when no statistics have been shown. In 1963, imports of oil from Cuba into the United Kingdom were recorded for the first time but there is insufficient information available to be able to assess what the future prospects for Cuban oil are likely to be.

Mexico

Lime plantings have increased in recent years and estimates are that 30,000 acres under limes in 1951 had risen to 31,000 acres by 1961 and could reach 50,000 acres by 1971. From 1951 to 1961, production of limes had remained fairly constant at about 68,000 tons a year.

The Mexican limes industry is regulated by the National Union of Lime Oil Producers, a quasi-Government organization. The Union regulates plantings, establishes quality specifications of both oil and juice and establishes a yearly quota of the quantity of lime oil that may be produced. The Union also claims to be active in developing new products, seeking new markets and developing new methods of sale of both juice and oil. Opponents of the Union claim that, because of its monopolistic position, it interferes with normal market processes. Most of Mexico's lime juice and lime oil is exported to the USA with the United Kingdom, France and Germany appearing as occasional buyers of juice and the United Kingdom and Canada have a small performance as buyers of oil.

Ghana

The Ghanaian industry has been set up by L. Rose & Co. Ltd. under Government auspices.

At present some 4,500 acres are planted with about 1 million plants and the average yield from mature, clean trees is about 165 lb. per tree annually.

A processing factory is in operation and fruit is collected up to a 15 mile radius from the factory.

Exports of lime juice have shown a generally increasing trend since 1957 and consignments are made only to the United Kingdom. No export figures of lime oil are available but, as with juice, most of it is probably shipped to the United Kingdom.

The Gambia

The industry in the Gambia is still only in the pilot stage and the Tropical Products Institute is closely concerned with its development. At present 15 acres are planted with 'Key' limes but there is, additionally, a plentiful supply of limes elsewhere in the Gambia.

Tanzania

A nucleus estate is being developed and smallholders are being encouraged to plant lime trees. A simple crushing mill has been installed and an ultimate production of 1 million gallons of juice a year was envisaged. It is rumoured that Tanzania has now embarked on a heavy planting programme which, if successful, may lead to a surplus of lime products in world markets.

United States of America

Nearly all US limes are grown in Florida and three-quarters of them are disposed of as fresh fruit. The fruit is a minor crop in terms of the US production of citrus fruit, accounting for some 0.2 per cent of the total.

For various reasons the lime industry has failed to show substantial growth and demand for lime juice in the USA is satisfied mainly from Mexico and from the

United Kingdom. However, total sales both to the fresh market and to the processors have increased steadily over the past ten years and so have imports. Thus it appears that, although there is a growing awareness of lime products in the United States, the imported juices are holding their own.

Florida lime-growers have, in the past, had little interest in converting their lime fruit into juice and oil and Florida lime oil has not been regarded as a commercial article. In the past ten or twenty years, however, increases in production and processing have led to the production of lime oil as a by-product of the extraction of the juice. Modern processes are employed whereby the oil can be separated without contact of juice and oil and it is claimed that this processing produces a more natural lime flavour. Nevertheless, the trade has become accustomed to the flavour of the old-fashioned distilled oil and, so far, seems to prefer it to any other. Consequently, there are high imports of oil entering the USA from Mexico, Haiti, Dominican Republic, Jamaica and Trinidad.

Prices in the UK

Up to some twelve months ago, there was a shortage of lime juice and prices rose to almost double the level of, say, four years ago, to 10s.6d. to 11s. per gallon c.i.f. for settled juice (maximum 2% pulp). At these prices lime juice was in danger of being priced out of the market and a more acceptable price to the merchants would be 8s. to 8s.3d. per gallon c.i.f. In fact, the general situation of supplies has changed quite dramatically in recent months and there now appears to be an oversupply position in the UK that has had the effect of lowering prices to about 8s. a gallon. This downward trend could continue if the coming season produces average crops.

Lime oil has also been in short supply and prices have risen to 60s. to 70s. per lb. c.i.f. compared with lemon oil at about 40s. to 45s. per lb. and sweet orange oil at about 5s. per lb. At these differentials there is a danger that the major users of lime oil will cease to include it in their formulations in favour of the cheaper flavouring oils.

The UK customs duty on lime juice imported from all countries except Commonwealth countries is 18 per cent *ad valorem* if there is more than 20 per cent sweetening matter added and 15 per cent *ad valorem* if less than 20 per cent sweetening matter is added. Juice of all kinds is admitted free from Commonwealth countries. Lime oil is duty free from EFTA and Commonwealth sources but attracts a duty of 25% *ad valorem* from all other countries.

There are no quantitative restrictions on imports of juice and oil into the UK but imports may be inspected at ports to ensure that they are fit for human consumption.

UK Market and Prospects

The United Kingdom market for citrus juices other than orange juice, grapefruit juice and mixtures of these grew at the rate of 3.8 per cent per annum in the period 1959 to 1965. The specific growth of lime juice demand cannot be assessed over this period but current demand is estimated at between 1¾ million and 2 million gallons, most of which comes from Commonwealth countries, particularly Ghana and the West Indies.

Jamaica, Ghana and the Windward Islands group are the principal suppliers of lime oil to the United Kingdom but both the USA and Mexico are also prominent suppliers.

The past few years have been a period in which considerably more interest has been shown by the public in lime juice than ever before. This interest has been stimulated by the sales efforts of L. Rose & Co. Ltd. but public taste may equally well alter in favour of some juice other than lime, especially if the price becomes too high. Thus the present level of demand may not be maintained.

About 95 per cent of the lime oil imported into the UK is used as a flavouring for food and drinks and the remainder is used in cosmetics, especially men's toiletries.

Although the prospect for lime products for the next few years appears to be one of limited sustained growth there are already a number of producing countries and newcomers will need to bear in mind the fact that, all things being equal, the supply of both juice and oil is sufficient to meet all demands. In these circumstances, and in view of the fact that it takes 8 to 10 years for lime trees to reach full bearing stage, development of new plantations or large capital investment in processing plant should be taken only after exhaustive enquiries have been satisfied as to the future of the market and after cognisance has been taken of the numbers of existing producers.

Western European Market and Prospects

There are reasons for believing that Continental Western Europe may take increasing quantities of lime juice during the next few years, although it is not possible to support this statement with any statistical data. The EEC countries will be difficult to break into because most will not permit the entry of juice preserved by SO_2 and this effectively excludes lime juice exported by L. Rose & Co. Ltd. The Scandinavian countries, especially Sweden and Denmark, have shown an interest in lime juice and sales to Sweden are now established.

The World Picture for Lime Juice and Lime Oil

Estimates of the future production of lime juice indicate that in 1971 it may be in the region of 4 million gallons against an estimated demand of about 3 million gallons. In the case of lime oil, world production has been estimated at 550 metric tons (1,212,542 lb.) against recorded imports in 1966 into the major markets, the UK and the USA of 924,000 lb.

Lime juice and lime oil production and markets

INTRODUCTION

Lime juice and lime oil are obtained from the fruit of *Citrus aurentifolia* Swingle which has two distinct groups, the acid limes and the sweet limes. Sweet limes grow wild and semi-wild in parts of South and Central America where the fruit has local appeal for its somewhat orange-like foavour, and oil from the peel of the sweet lime was marketed in the USA as a substitute for Italian Bergamot oil during the years of World War II when the source of supply of Bergamot oil was cut off. Subsequently, supplies of the Bergamot oil became available, and since the juice of the sweet lime is too insipid for wide usage the sweet lime lost all commercial importance.

Commercial production today of lime juice and lime oil therefore comes from the acid varieties of lime fruit, two varieties of which are the most important: one is the Mexican, or West Indian or Key variety, the other is the Tahitian, Persian or seedless lime. This report examines the limes industry in the main areas of commercial production, namely, the Caribbean, Mexico, the United States and Ghana. Reference is also made to developments in the Gambia and Tanzania. The report considers the market prospects for the juice and oil made from the acid varieties of limes only.

Lime juice was used medicinally – as an anti-scorbutic – long before it was regarded as a beverage. Lime oil is used extensively as a flavouring in food products, confectionery and beverages. It is also used in perfumes, toilet waters, cosmetics and soaps. Lime juice and oil is referred to by various descriptions. These descriptions, as used in this report, have the following meanings:-

Raw juice

This is the juice as it is obtained from the crushed limes before any further treatment is carried out. Raw juice contains pulpy matter from the expressed limes.

Settled or racked juice

When raw juice is allowed to settle in vats the heavier pulpy matter settles at the bottom and the fine, light pulp and oil rise to the surface. The intermediate layer of juice is left fairly clear; this is settled or racked juice.

Filtered juice

Settled or racked juice is not completely clear and can be filtered to remove particles of pulpy matter.

Clarified juice

A final filtering operation is carried out to obtain a clear, or clarified, juice. It is commonly carried out in the importing country but some producing areas export a clarified juice.

Concentrated juice

The water is removed from the juice, usually by the application of heat at reduced air pressure, until the desired degree of concentration is obtained.

Top juice with pulp

The fine light pulp with oil and juice that rises to the top of the settling vats.

Ecuelled oil

The écuelle consists of a shallow bowl of copper with a hollow central tube with which it forms a funnel. The bowl is equipped with large brass nails with blunt ends, across which the fruit is rolled by hand until the entire surface of the fruit has yielded its oil which dribbles down the central tube into a container.

Distilled oil

Following the racking process, the top juice with pulp and oil and the lower layer of heavier pulpy matter are drawn off and run into stills. There are various methods of distillation, perhaps the most usual being by direct and indirect steam.

THE LIMES INDUSTRY IN DOMINICA

While the production of limes in Dominica is small compared with that of producers like Jamaica and Mexico, the crop is of great importance to the economy of the island and, in 1963 (the last year for which figures are available), raw lime juice and essential oil of lime together were the second largest export of Dominica, accounting for almost 14 per cent of her domestic exports. Even so, these figures show a decline from the previous year when exports of juice and oil combined were almost 20 per cent of domestic exports and the later figures recorded a reduction in value of nearly 44 per cent(1).

In the West Indies Census of Agriculture,1961(2), the area under limes is recorded as being 2,290 acres on compact plantations, of which more than two-thirds is grown on holdings of more than 50 acres and nearly 40 per cent is on holdings of over 500 acres. Further details are given in the following table:

Limes: Area and number of trees, by size of holding, in Dominica 1961

SIZE GROUP (ACRES)											
Area in compact plantations:			0	1-	5-	10-	25-	50-	100-	200-	500+
TOTAL	Acres	2,290	-	208	74	139	99	177	176	576	841
Non-bearing		135	-	43	7	8	1	16	-	40	20
Bearing		2,155	-	165	67	131	98	161	176	536	821
Total trees on holdings:											
TOTAL:	Trees	286,324	2,372	41,825	16,983	30,858	10,839	19,190	18,433	59,071	86,753
Non-bearing		23,405	211	6,239	4,444	4,078	173	2,000	200	4,060	2,000
Bearing		262,919	2,161	35,586	12,539	26,780	10,666	17,190	18,233	55,011	84,753

Source: *Extract from Report on West Indies Census of Agriculture, 1961.*

There is a small local trade and a small export trade in fresh limes, mainly during the tourist season, December to April, but the bulk of the lime crop is disposed of to local processors. Limes for processing are not normally picked from the trees but are collected when they ripen and fall to the ground. The prices paid by the processors to growers have varied widely over the past few years according to the demand for juice and oil. At the time of writing, the price paid was WI $5.80 per barrel of 160 lb. containing 1,200 to 1,500 limes. In addition, an allowance was made to cover transport of the limes, varying from 20¢ to 75¢ per barrel depending on the distance of the growing area from the factory.(3)

There are reported to be eight plants expressing lime juice on the island but only two of these undertake the full treatment of settling, clarification and casking: these are L. Rose & Co. Ltd., the island's largest processor and Messrs. A.C. Shillingford & Co. One firm exports pulpy juice and the others express the juice for sale to either Rose's or Shillingford's. Shillingford's do not sell concentrate juice because they consider that concentrated juice loses some flavour in export transit. Rose's operate a concentration plant which produces 4 gallons of 5 : 1 concentrate per hour, that is, 5 parts of single-strength juice produce 1 part of concentrated juice.

Dominica's total juice settling capacity is 250,000 gallons of which Rose's own 130,000 gallons capacity and Shillingford's 46,000 gallons. The vats are constructed of wood and the raw juice is allowed to settle in the vats for two or three weeks. This permits the heavier detritus to settle at the bottom and the fine, light pulp and oil to rise to the surface. The intermediary layer of juice will be relatively clear and can be drawn off and sold as 'settled' or 'racked' juice. The upper layer is sometimes exported as 'top juice with pulp' but normally is distilled locally to obtain the essential oil of lime.

Average yields from 1 ton of limes are 70/80 Imperial gallons of settled juice and 4 to 6 lbs. of oil. A yield of 75 per cent settled juice is expected from the raw juice. The settled juice used to be exported in once-used whisky barrels obtained from the USA but revised legislation in the USA permitting whisky distillers there to use the barrels more than once created a shortage for use in Dominica. However, this problem has now been resolved and the juice is being shipped in White Fir or Oak barrels of 40-42 gallons and is preserved by sulphur dioxide, usually in the proportions of 600 parts per million.

It is necessary to point out the fundamental difference in outlook that there has been between L. Rose & Co. Ltd., and the other processors. Rose's have been primarily concerned with the market for lime juice for sale through their

organisation as 'Rose's Lime Juice'. Juice surplus to their requirements is sold to other soft drink manufacturers. Lime oil has been of secondary significance. The problem of finding a market for juice has been, until recently, more formidable for the other processors and at some of the low price levels recorded in the past few years for lime oil, processing for oil without an assured market for juice has been unprofitable.(4)

Until recently, however, demand for juice and oil was outstripping supply and prices of both increased, as will be discussed in a later section of this report.

In Dominica, oil is obtained from the fruit in two ways. A small proportion is obtained by the old-fashioned method of "ecuelling". The ecuelle consists of a shallow bowl of copper with a hollow central tube with which it forms a funnel. The bowl is equipped with large brass nails with blunt ends, across which the fruit is rolled, by hand, until the entire surface of the fruit has yielded its oil which dribbles down the central tube into a container. The yield of oil depends on the condition of the fruit and on the skill of the operator bus is usually very low and is, on average, 2½ to 3 ozs. of oil per 160-lb. barrel of fruit(5). The distillation method is the one mostly used in obtaining oil. Following the racking process, the 'top juice with pulp and oil' and the lower layer are drawn off and run into stills. One hundred gallons of juice yield an average of 4-lb. of oil. If the limes have been ecuelled prior to crushing, the yield of distilled oil is of course lower. Fresh picked limes can give as much as an average of 8½ ozs. of oil per barrel of 160-lb. of fruit(5) compared with the 5½ to 6 ozs. of oil obtained from the ripe fallen fruit which is the best for juice extraction. Thus the processor faces the dilemma of whether he should regard lime oil as a primary or as a secondary product and the decision can only be made in the context of the processors' outlets for both and their related prices.

Details of exports from Dominica of (a) settled and (b) other types of lime juice (top pulp, raw, sweetened and concentrated) are given in Tables 1 and 2 in the statistical appendix. The period covered by the statistics in 1957 to 1966. However, a breakdown of exports according to type of juice is not available for the years 1959, 1960 and 1961. Table II over summaries exports of all types of lime juice. In the figures for the years 1962 to 1966 the quantities of concentrated juice exported are expressed in terms of their equivalent as settled juice.

Table II

Exports of lime juice of all types from Dominica, 1957-66

	thousand gallons
1957	449.1
1958	726.5
1959	721.1
1960	443.0
1961	89.0
1962	701.9
1963	473.0
1964	356.2
1965	527.3
1966	602.7

It will be seen that the annual exports have varied considerably during the period under review. The decline after 1959 may have been partly due to a policy

encouraged by the authorities of replacing old, uneconomic trees with new stock that would take some time to come to full-bearing. (It takes from 8 to 10 years for lime trees to reach full bearing). However, it is known that Rose's began to make concentrated lime juice in 1960 and this may additionally explain the very low export figure for 1961; the figure would be higher if the unknown element of concentrated juice were expressed in terms of its equivalent as settled juice. In 1962, exports of settled juice were low at 19,000 gallons but in that year there was a substantial export of 113,000 gallons of concentrated juice. In the following year, the island was affected by hurricane 'Edith' and exports declined of both settled and concentrated juice to 21,000 gallons and 85,000 gallons respectively. From 1964 there was a general upturn in exports of all types of juice. Settled lime juice sales were 153,000 gallons, concentrated 32,000 gallons and top pulp 27,000 gallons. These three constituted the main exports of juice but additionally some raw and sweetened juices were exported. The following year, 1965, showed an increase to 291,000 gallons of settled juice and an increase in the sale of top pulp was also registered, 104,000 gallons being disposed of. Concentrated sales fell slightly to 25,000 gallons. In 1966, sales of settled juice and top pulp declined to 178,000 gallons and 35,000 gallons respectively but sales of concentrated juice rose to 98,000 gallons.

The biggest market for Dominican lime-juice is the United Kingdom, a natural outcome of British influence in the Caribbean and the development of the interests in limes of L. Rose & Co. Ltd. Other markets are the United States and Canada.

Exports of lime oil from Dominica are given in Table 3 of the statistical Appendix. Exports consist mainly of distilled oil. Small quantities of ecuelled oil and oil in suspension in juice are exported from time to time, but the trade in these is insignificant. Exports can vary considerably from year to year: no trend is discernible. The UK is by far the principal market.

THE LIMES INDUSTRY IN OTHER CARIBBEAN AREAS

Jamaica

While the production of limes in Jamaica is relatively large compared with that in Dominica, its importance to the agricultural economy of the island is much less(4).

The limes are grown mainly as a pasture crop on grazing land or are inter-planted between coconut trees. No reliable data is available as to total acreage under lime cultivation. In 1961(6), there were eight factories in Jamaica processing and canning fruit products but since the details available concerning their activities do not include the processing of limes it must be presumed that this is generally a minor aspect of their operations. However, it is known that two firms control a lime juice capacity of 650,000 gallons and that these two firms are the principal producers in the island.

Exports of lime juice from Jamaica go almost entirely to the United Kingdom and trade with other countries is negligible. Details of the trade are given in Table 4 from which is will be seen that sales of juice have shown a tendency to increase in the period 1957 to 1965. The annual average volume of exports from 1958 to 1961 was 392,000 gallons. This rose to 502,000 gallons in the period 1962 to 1965, an increase of 28 per cent. The year 1965 was the peak year of the nine-year period from 1957, 619,000 gallons being exported, of which 598,000 gallons or nearly 97 per cent went to the United Kingdom. The unit price of lime juice has also shown a tendency to increase: in 1957 it was about sh. 5s. per gallon calculated on the basis of the f.o.b. price; in 1962, the peak year before the record year of 1965, it was again around sh. 5s. per gallon and, in the three years 1963, 1964 and 1965 the prices realized were in the region of

sh. 5s., 5s.4d. and 6s. per gallon respectively.

The pattern of exports from Jamaica of lime oil (Table 5) is similar to that of lime juice in that nearly all shipments are made to the United Kingdom. Annual average exports of oil between 1962 and 1965 were, at 56,000 lb. 12 per cent greater than the annual average of 50,000 lb. for years 1958 to 1961.

Average unit prices for oil have also shown a tendency to increase, from around sh. 35s. per lb. in 1957 to sh. 41s., sh. 43s.6d. and sh. 45s. per lb. in 1963, 1964 and 1965 respectively.

Grenada

Exports of lime juice and lime oil from Grenada are given in Tables 6 and 7. Since 1962, exports of lime juice have tailed off considerably, and totalled only 3,000 gallons in 1965 compared with 12,000 gallons in 1962 and the peak of 76,000 gallons in 1960. In 1963, the island was struck by hurricane 'Edith' and considerable damage was caused to crops. The lime juice is sold to Dominica and Trinidad.

Although Grenada is still a comparatively small-scale producer of lime oil, her exports (shown in Table 7) have expanded considerably in recent years, undoubtedly in response to the higher prices that lime oil has been commanding on the world market. Thus in the period 1957 to 1962 the highest recorded exports of lime oil were 1,700 lbs. in 1958, whereas in the three years 1963 to 1965 (the latest year for which statistics are available) exports averaged 3,600 lbs. per annum.

The UK is usually the main market for lime oil from Grenada, but, in 1965, 3,600 lbs. went to various unspecified countries, the balance of 2,000 lbs. being sold to the UK.

Guyana

Guyana's lime juice exports, which consist mainly of settled juice, have varied considerably between 1957 and 1964, the years covered in Table 8. From a peak in 1957 of 17,000 gallons exported, shipments fell away, except for a slight recovery in 1959, to only 100 gallons in 1962. The decline in shipments is attributed to low world prices, which made collecting and processing the limes uneconomic. In 1963, several of the West Indian islands suffered damage from the hurricanes 'Flora' and 'Edith' with the result that supplies of West Indian lime juice and oil became restricted and prices began to rise. In 1964, exports from Guyana rose significantly to 11,000 gallons, the highest level reached since 1959 (Guyana did not publish trade figures in 1963). The principal market is the United Kingdom. Exports of lime oil were small between 1957 and 1962 and only once, in 1958, did they exceed 1,000 lbs. In 1964, however, exports reached a record 7,000 lb., of which 5,600 lb. was distilled oil and 1,400 lb. ecuelled oil. Exports of lime oil are given in Table 9. The UK is by far the largest market.

In Guyana all the distilled oil produced in exported.[7] The ecuelled oil, on the other hand, is used almost exclusively in the manufacture of a locally-made product, 'Limacol', a toilet water. The manufacturer of this product also imports a certain quantity of the ecuelled variety, partly for blending purposes but also as a safeguard against possible crop failure. Any ecuelled oil produced in excess of the local demand is exported. Occasionally, a small quantity of distilled lime oil is imported as a flavouring for locally manufactured confectionery. Imports of lime oil into Guyana are shown in Table 10.

Trinidad and Tobago

A survey of the citrus industry made in 1956 indicated that citrus occupied nearly 10,000 acres, but it is impossible to say what proportion of this is devoted to lime cultivation. There are no lime groves as such, the fruit being grown among other crops, mainly by small-holders, as a cash crop.

Production of limes has been adversely affected by loss of trees from disease. Some effort has been made to replace losses by replanting 'budded' limes on disease-resistant root-stocks. However, the economic importance of limes in these islands, compared with other types of citrus, is relatively small. Prices to growers have varied considerably and at times have been so low as to make it uneconomical for the growers to collect their fruit.(8) However, the present outlook is more encouraging and the local growers have been planting additional trees which will mean some additional fruit in two to four years time.(9)

There is at present only one processing plant on the islands, operated by Trinidad Lime Products Ltd. The average yearly quantity crushed is 3 million pounds of fruit, with an approximate yield of 93,000 gallons of settled juice and 10,000 lbs. of distilled oil. No concentrated juice is produced.(9)

Exports of lime juice from Trinidad and Tobago are shown in Table 11. It will be seen that exports vary considerably from year to year.

From 1957 to 1959 exports of clarified and filtered juice, which constitutes the bulk of the export total, declined from 61,000 gallons to 52,000 gallons but there was a sharp, nearly four-fold, increase in 1960 to 201,000 gallons. The reason for the increase was that the United Kingdom purchased from these territories considerably more juice than previously. In 1961, exports dropped back to a mere 26,000 gallons but climbed again in 1962 to 91,000 gallons. In 1963 and 1964 exports declined slightly to 75,000 gallons and 84,000 gallons and fell away even further in 1965 to only 47,000 gallons. After the United Kingdom, the USA and Canada are Trinidad's best markets.

Exports of lime oil are given in Table 12. Like the lime juice exports, exports of oil show considerable annual variation. However, on balance exports tended to increase between 1957 and 1962 and in the latter year reached 22,000 lb. of which 15,000 lb. were purchased by Bermuda. Bermuda is, however, an erratic purchaser of lime oil. In 1963 she did not appear in the market and Trinidad's exports of lime oil declined sharply, to 5,000 lbs. In 1964, they increased again, to no less than 34,000 lbs., of which Bermuda purchased 29,000 lbs., but in the following year when Bermuda purchased only 2,700 lbs., Trinidad's exports declined sharply once more to only 8,800 lbs. The likelihood is that Bermuda's purchases are of a speculative nature. The figures certainly suggest that she cannot be relied upon to provide an outlet for Trinidad's exports, but at the same time they show that when markets are available Trinidad can substantially increase her supplies of lime oil. Apart from Bermuda, the UK and Canada are Trinidad's main customers. During the period under review the purchases of both countries have shown similar trends, namely, declining in the earlier years and showing an upward trend in more recent years.

The bulk of Trinidad's exports are in the form of distilled oil although occasionally very small amounts of ecuelled oil are exported.

Montserrat, St. Lucia, St. Vincent

Figures for exports of raw lime juice from Montserrat are given in Table 13: in 1964 they were 14,000 lb., the highest level since 1958. The year 1963-64 saw marked progress in the general economic development of Montserrat(10) but there is, at present, insufficient information to show whether this progress will be reflected in the limes industry. The United Kingdom and Canada, with whom Montserrat has commercial links, are the two best markets for lime juice and it is

understood that a Canadian company in Montserrat buys limes for sale of raw juice to Dominica for further processing there. No oil is exported from the island.

The small production of lime juice on St. Lucia has declined and no export trade is recorded after 1961. The figures for 1957 to 1961 are given in Table 14 and show that exports of lime juice during those years did not exceed 5,500 gallons per annum.

St. Vincent exports ecuelled lime oil but the amounts involved (see Table 15) are very small and in some years no shipments are made. The UK is the only customer. There is the possibility of private development of lime growing on St. Vincent. Tentative plans are to propogate limes by building up 30,000 lime trees for the planting eventually of about 500 acres and, by 1971, some 3,000 tons of limes a year might be expected.

Haiti and Cuba

There are no recent figures of Haitian production of lime oil. Lime juice does not appear to be produced there. Most of the oil is probably exported to the United States although, in 1965, nearly 4,500 lb. was shipped to Australia according to the Australian trade returns, the first and only time any trade had been recorded with this country in the period 1961 to 1966 inclusive. The United States import figures are fairly substantial and have shown a tendency to increase. In the period 1957 to 1961 the annual average volume of imports into the USA from Haiti was some 42,000 lb. whereas from 1962 to 1966 the annual average rose to 87,000 lb.

Cuba had a small, but growing, share of the lime oil market in the United States up to 1960, but since then she is not shown as a supplier in the United States statistics. In 1963 the UK recorded imports from Cuba for the first time for several years. These amounted to 14,000 lb. and rose to 18,000 lb. in 1964. However, there was a fall-off in 1965 and 1966 when preliminary figures showed imports to be only 4,000 lb. and 6,000 lb. respectively. Cuba does not appear to export lime juice.

THE LIMES INDUSTRY IN MEXICO

The past fifteen years have been years of rapid development in Mexico, and as the infrastructure of the economy has improved the citrus industry has expanded considerably,

Orange plantings have shown the greatest development, but lime plantings have also increased. In 1951, it was estimated that there were 30,000 acres under limes. By 1961 the acreage had risen only to 31,000. However, it is now estimated that lime plantings could reach 50,000 acres in 1971.[11]

From 1951 to 1961, the last year for which production figures are available, production of limes had remained fairly constant at about 2 million boxes (each of 76-lb.), that is, almost 68,000 tons per year.

The main production area for limes is in the state of Colima, which accounts for over 40 per cent of the Mexican output. Areas of smaller production are the states of Michoacan, Vera Cruz and Tamaulipas and, it is believed, considerable interest is being shown in plantations in the north of the country. The bulk of the production is disposed of as fresh fruit, but between 1951 and 1961 Mexico nearly doubled its processing capacity to about 600 to 800 short tons a day. However, only a small part of the capacity was in fact used to process limes because of the lack of markets for juice and essential oil. The increased plantings, combined with the lack of markets, resulted in a glut of lime juice and oil. This

situation was further complicated by the fact that part of the processing was done by plants controlled by semi-government agencies which, by law, were compelled to accept quantities of fruit and, therefore, to act as surplus disposal agencies. This situation prompted the Government to establish the Union Nacional de Productores de Aceite de Limon (National Union of Lime Oil Producers), a quasi-Government organization formed to regulate the Mexican limes industry. Its Board of Directors includes representatives of the Ministeries of Agriculture, Finance, Industry and Commerce, and the Bank of Mexico.

The Union regulates plantings, establishes quality specifications for lime oil and lime juice, and issues all export permits for lime oil, which has to conform to the Union's quality Standards.

The Union establishes a yearly quota for the quantity of lime oil, both distilled and cold-pressed*, that may be produced. Each year the market situation is assessed and an estimate made of the quantity of oil it will be possible to use in the domestic market and to export. Based on this estimate, quotas are given to each lime oil producer. The annual total production quotas are equal to the estimated quantity required in the market, plus 10 per cent.

The Union also claims to be active in developing new products, seeking new markets and developing new methods of sale of both juice and oil.

The Union has been a controversial organisation mainly because private processors object to its monopolistic position and claim that it interferes with normal market processes. The Union, on the other hand, claims that it has improved the quality of lime products and brought some stability to the market. Despite the opposition, it is understood that the Union is still operating as a regulatory agency.

The exports of lime juices from Mexico shown in Table 16 illustrate the fluctuating nature of the trade between 1957 and 1965. Following exports of 222,000 gallons in 1957, sales fell substantially in 1958 to 83,000 gallons. In that year, hurricane damage severely affected the output from Colima and exports fell again in 1959 to 73,000 gallons and to 20,000 gallons in 1960. In 1961 there was an improvement but this was not maintained in 1962 and it was 1963 before any marked upturn was recorded when 120,000 gallons were exported.

There was a fall to 93,000 gallons in 1964, mainly because of reduced exports to the USA which were not offset by the first substantial exports to the United Kingdom for five years, amounting to 43,000 gallons. In 1965, there was a considerable increase in exports to a total of 416,000 gallons of which 305,000 gallons were shipped to the United Kingdom and 110,000 gallons to France. Most of the lime juice is exported to the United States (which has long sustained the Mexican trade), with the United Kingdom, France and Germany appearing as occasional buyers. A very small proportion of Mexico's exports of lime juice is understood to consist of concentrated juice, but actual figures are not available.

Exports of lime oil from Mexico as shown in Tables 17 and 18 have shown a tendency to rise between 1957 and 1965. In the four years 1957 to 1960 exports of lime oil averaged 265,000 lb. annually compared with annual average

---

*Cold-pressed oil is that obtained when the pulp and juice have been reamed out of halves of the fruit, leaving only the skins in which the essential oil remains. The skins are submitted to a very high pressure (for example, between rollers or screw presses) so that the aqueous cell liquid and part of the essential oil are expressed. Supercentrifuging will then yield the 'cold-pressed' oil.

exports of 451,000 lb. in the following five years up to 1965, an increase of 70 per cent. As in the case of lime juice, exports of lime oil in 1965 were at the highest level reached during the period under review. Lime oil is exported in quantity to the USA and, to a far lesser degree, to the United Kingdom and Canada. For example, in 1965, 600,000 lb. of oil were sold to the USA compared with 23,000 lb. to the United Kingdom and 1,000 to Canada.

THE LIMES INDUSTRY IN GHANA

The Ghanaian industry has been set up by L. Rose & Co. Ltd., under Government auspices. The potential lime area in Ghana is reckoned to be about 128,000 acres but, at present, some 4,500 acres are under approximately 1 million budded/grafted and seedling plants and the annual average yield from mature, clean trees is about 165 lb. per tree – considerably less if the trees are disease infected[12]. Disease has reduced yields from time to time and led to reductions in exports but control measures are quickly taken by the Department of Agriculture and by the local representatives of L. Rose & Co. Ltd. A processing factory is in operation and is sited in an area in which the local farmers have planted trees supplied from nurseries, both private and belonging to the factory. Fruit is collected up to a 15-mile radius from the factory. The limes are not picked from the trees but are collected from the ground during the rainy seasons (February – April and July – November). This has the disadvantage of making the fruit dirty so that a thorough washing is needed before processing to remove dirt and fine grit. The fruit in the area appears to be consistent in size (10 or 12 to the lb.) and matures to a good yellow colour.

Exports of lime juice from Ghana have shown a generally increasing trend since 1957 when 224,000 gallons were exported. They rose to 945,000 gallons in 1962 but there was a set-back because of disease in the following two years to 766,000 gallons and 612,000 gallons in 1963 and 1964 respectively. In 1965, there was a marked surge in exports to over one million gallons, and, it was estimated that in 1967 production would reach 1¼ million gallons most of which would probably be exported. Because of the unique position of L. Rose & Co. Ltd. in Ghana it is inevitable that exports since 1961 have been consigned only to the United Kingdom. Details of lime juice exports are given in Table 19.

Figures for the export of lime oil are not available, but it is likely that, as with juice, most of the oil is shipped to the United Kingdom. In 1966, United Kingdom imports of the oil, which is obtained by distillation in the L. Rose factory, were about 28,000 lb., an increase of 5,000 lb. over the 1965 figures and of 7,000 lb. over the 1964 total. It was expected that this figure would increase again in 1967.

THE LIMES INDUSTRY IN THE GAMBIA[13]

This Institute is closely concerned with a pilot scheme to develop a lime-processing industry in the Gambia where there are, at present, two sites – one of 5 acres and the other of 10 acres – under 'Key' limes. In addition, 500 acres once used for poultry production could be brought into the scheme if the limes project justifies further development. Some of the lime trees on the 15 acres are in poor condition but indications are that there is a plentiful supply of limes elsewhere in the Gambia. However, with adequate fertilising, 70 tons a year is considered possible from the two sites. From Gambia as a whole it appears that at least 200 tons of fruit a year is likely at the price of 2d. per lb. instead of the originally anticipated quantity of 100 tons.

The pilot plant consists of a small roller-mill with granite rollers, six wooden vats each of 500 gallons, a stainless steel, 100-gallon, still and various other minor items of ancillary equipment. During the first season's working (September to November 1967) it became apparent that there was far more fruit available than had previously been supposed and so it has been considered advisable to purchase

a larger roller-mill with a capacity of 2 tons of fruit an hour which can, it would seem, operate economically running only 2 hours a day.

Yield estimates* are that 1 ton of limes will produce 100-120 gallons of pulp/juice. After settling and treatment, 7 to 8 drums x 45 gallons of racked juice should be yielded from one vat. The top and bottom pulps remaining in the vats are for combining and distilling and the yield of oil should be 20-25 lb. from 4 tons of limes. Export packing is, for juice, in 45- gallons, fusion coated, steel drums and, for oil, in 4-gallon, tin-plated drums.

The first season's output from the pilot plant was 2,193 gallons of juice and 115 lb. of oil. Contracts had previously been arranged to sell the juice at sh. 10s. per gallon c.i.f. and the oil at sh. 67s.6d. per lb. c.i.f.

LIMES INDUSTRY IN TANZANIA

A company has been formed to exploit lime production in southern Tanzania. A 200-acre nucleus estate is reported to be in course of development with lime trees planted 170 to the acre and expected to come into limited commercial production five years from planting.

Smallholders are being encouraged to plant lime trees and are given free seedlings from the nurseries of the Government and the nucleus estate.

Mature trees, six years of age in the Government station are giving 280 lb. of fresh fruit per tree per annum but calculation for future yields from both plantation and smallholders are based on only 84 lb. per tree per annum.

The price to be paid to the growers for fruit is EA sh. -/75 cents (say 9d.) per 28 lb. which may be raised to 1s. for 28 lb. at some unspecified future date.

A simple crushing mill has been installed which produces juice at about 90 gallons per 1 ton of firm fruit. The mill is paid sh. 3/50 per gallon for the juice ex-mill. Casking, transport and all charges to c.i.f. UK port add approximately a further sh. 3s. per gallon.

It is understood that a target of 1 million gallons of juice per annum was envisaged but it is now rumoured that Tanzania has embarked on a large lime planting programme that may lead to a surplus of lime products on the world markets in future years. At the time of writing factual details are not known.

No export figures are given by Tanzania for lime oil and juice exports are categorized under the heading of 'Juice of Fruit and Vegetables other than Passion Fruit, Pineapple and Tomato'. It is, therefore, impossible to single out lime juice but exports of juices in this residual category in the four years available 1964 to 1967 fell from 150 tons in 1964 to 92 tons and 76 tons in the following two years respectively, rising to 120 tons in 1967. In the same four years, exports to the UK were 34 tons, 28 tons, 20 tons and 34 tons respectively but how much of these quantities might be lime juice is impossible to say.

THE LIMES INDUSTRY IN THE UNITED STATES OF AMERICA

Nearly all US limes are grown in Florida and three-quarters of them are disposed of as fresh fruit. The fruit is a minor crop in terms of US citrus fruit production

---

*The yields of juice and oil obtained from processing one ton of limes in the Gambia are similar – though perhaps marginally better – to the yields obtained in Dominica.

which, in the 1965-66 season, totalled over 8½ million tons, of which limes accounted for some 17,000 tons or 0.2 per cent. The limes not sold as fresh fruit usually go for processing into limeade concentrate but the lime is generally regarded as a luxury fruit compared with oranges and lemons and the demand is dependent, to a large extent, on the weather. Heavy advertising and good marketing have created a demand for lemon products with which the smaller lime industry has not been able to compete. It has also been suggested(14) that, for processing purposes, the Florida lime crop has a difficult harvesting season. The limes start coming into production in May, reach a peak during June and July and maintain a good level through October, after which there is a marked decline in volume. In general, growers find that the new crop of limes brings better prices when shipped as fresh fruit up to about the middle of July and processors get only the off-grade fruit until this date. Afterwards, the price of fresh fruit drops off and all grades of fruit then become available to the processors. However, since limeade is primarily a hot weather drink the wholesale demand for limeade ceases in early August since by the time the new concentrate reaches the customer the hot weather is over. Thus the concentrator must process in August, September and October and carry frozen stocks until the following spring.

A further reason can be put forward for the failure of the lime industry to show marked growth and that is the fact that only a very small part of the Florida lime groves are under West Indian limes, which give the brightest and most delicate flavour of lime juice. Consequently, demand for lime juice in the United States is satisfied mainly from Mexico and, following a determined sales campaign by L. Rose & Co. Ltd., from the United Kingdom.

The West Indian lime is confined mainly to the Florida Keys and to the southern tip of the mainland. Because of its sensitivity to climatic conditions, especially frost, the West Indian lime has been superseded in most commercial groves by the Persian lime.

Despite the poorer quality of the juice of the Persian lime there is nevertheless a considerable amount of fruit processed annually in the USA as the following table shows:

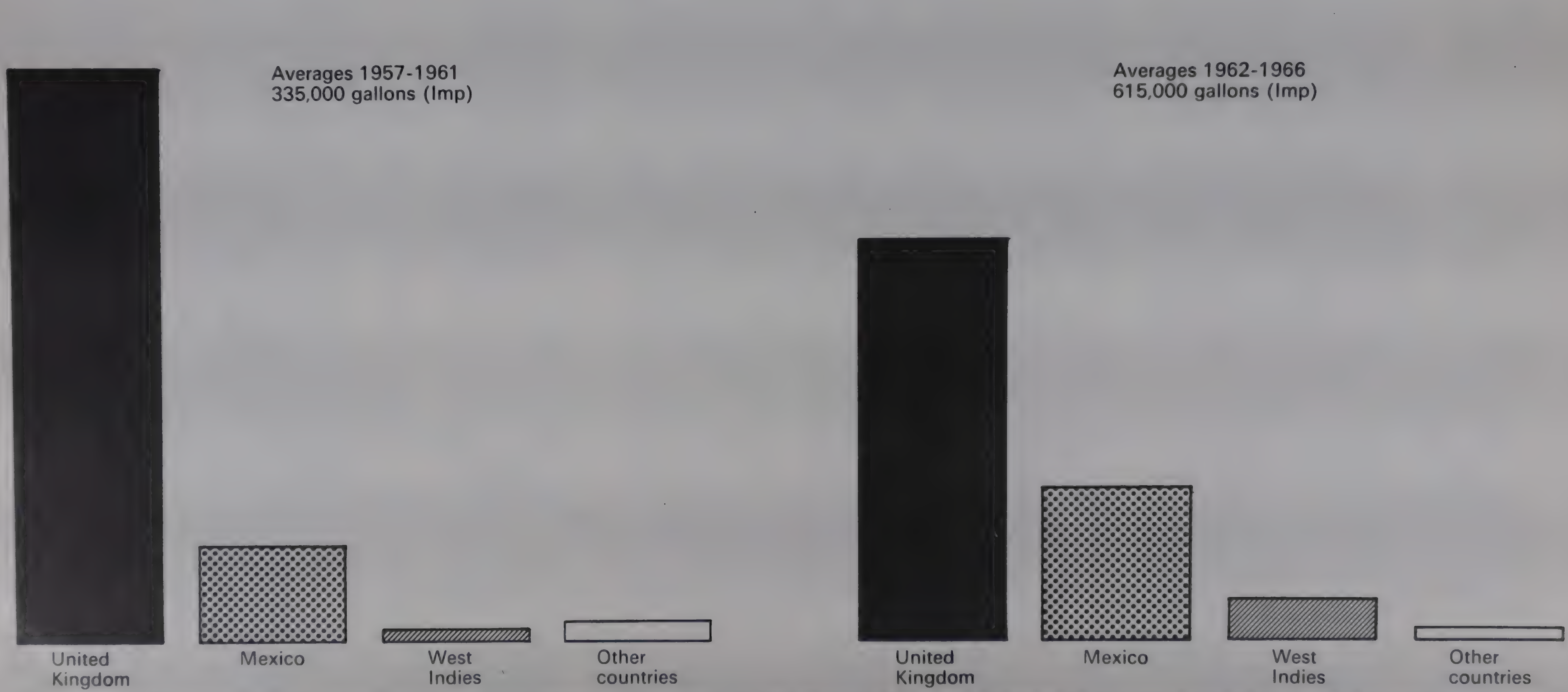
Table III

Limes: Sales in USA 1954-55 – 1964-65

	Total sales	Fresh sales	Sales to processors
1954-55	15,200	11,880	3,320
1955-56	16,000	12,000	4,000
1956-57	16,000	8,160	7,840
1957-58	14,000	11,040	2,960
1958-59	7,800	5,000	2,800
1959-60	12,600	7,960	4,640
1960-61	12,200	7,760	4,440
1961-62	13,400	7,320	6,080
1962-63	15,800	9,240	6,560
1963-64	17,800	9,280	8,250
1964-65	22,200	11,800	10,400

Source: "Citrus Fruits". *Statistical Bulletin No. 380 US Department of Agriculture. Crop Reporting Board, January 1967.*

Figure 1
Lime juice Imports into United States



Imports of juice increased so that although there seems to be a growing awareness of lime products in the United States, it appears that the juice from the imported West Indian lime is holding its position and, possibly, retarding the growth of the Florida limes industry.

Imports of lime juice are given in Tables 20 and 21. It will be seen that there has been a marked increase in imports of concentrated juice since 1960, with the United Kingdom and Mexico appearing as the usual suppliers. In 1962 and 1963, Mexico became the principal supplier, shipping 116,000 gallons and 212,000 gallons respectively. After 1963, the USA included imports of concentrated juice with those of unconcentrated. The UK is the largest exporter (shipping an annual average of 406,000 gallons between 1962 and 1965), followed by Mexico, and most of the imports from UK are likely to be of the clear, racked juice marketed through the L. Rose organisation. Imports have shown a propensity to rise in recent years probably because of the growing popularity of lime juice as a mixer in alcoholic drinks.

In Florida, the production of lime oil is a by-product of the extraction of the juice for canning. The most efficient of the plants aim at extracting the juice and the oil in one operation, but this produces an oil which is different in odour and flavour from the distillation process commonly used in the West Indies and Mexico whereby the oil is distilled from the hot, acid juice. In the modern process the oil can be separated without contact of juice and oil. It is claimed that this modern process produces a more natural lime flavour but that, nevertheless, the trade has become accustomed to the flavour of distilled lime oil and, so far, seems to prefer it to any other. This explains the high imports of lime oil entering the United States of America from Mexico and the West Indies, especially Haiti and, to a lesser degree, from the Dominican Republic, Jamaica and Trinidad. The largest supplier to the USA is Mexico, and average annual imports into the USA in the five years 1962 to 1966 were 495,000 lbs. compared with the annual average for the previous five years of 296,000 lbs; and in 1966 were recorded the highest imports from Mexico for the decade at 587,000 lbs. Haiti has also increased their exports to the USA, although the quantities are not on such a large scale as those sold by Mexico. In the five year period 1957 to 1961, average annual imports from Haiti were some 44,000 lb. whereas in the period 1962 to 1966 they had increased to 89,000 lb. The year 1966 was, as in the case of imports from Mexico, a record year and 104,000 lb. were purchased from Haiti.

Imports from the Dominican Republic are comparatively small and in recent years have been in the region of between 8,000 and 13,000 lb. Jamaica and Trinidad are small suppliers to the United States, shipping annually only a few thousand lb., except in 1966 when Jamaica sold 16,000 lb. Details of imports of lime oil into the United States of America are shown in Table 22.

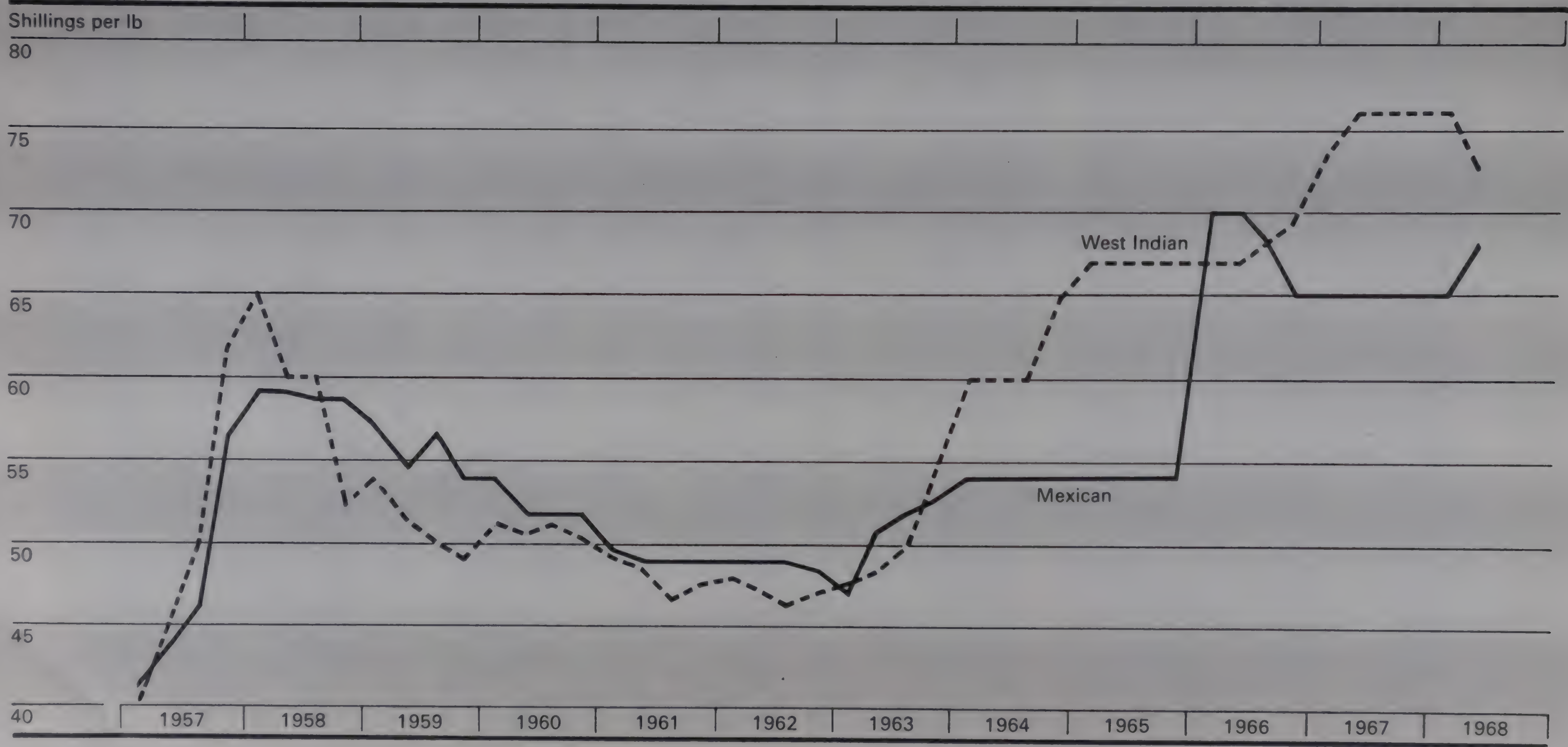
THE PRICES OF LIME JUICE AND LIME OIL IN THE UK

Unlike those for lime oil, the market prices for lime juice are not published on a regular basis and recourse to trade sources has been necessary. There is currently a surplus of lime juice but until recently there was a shortage and producers were being paid about double the price they would have accepted, say four years ago. For example, in 1963, one merchant was paying between 5s.6d. and 6s. per gallon for settled juice (maximum 2% pulp) c.i.f. London terms, whereas the price until recently was between 10s.6d. and 11s.6d. per gallon. It is now about 8s. per gallon.

In addition to the scarcity of the product, two other factors contributed to the increase in the price of lime juice namely, the high cost of barrels, which were in very short supply but are now more easily obtained, and increased freight.

At the prices of 10s.6d. to 11s.6d. per gallon the trade consider that lime juice is in danger of being priced out of the market. It is said that, in order to take

Figure 2
Lime oil Quarterly average prices, c i f London



advantage of the greater interest in and demand for lime juice, a more realistic price would be 8s. to 8s.3d. per gallon c.i.f. which is the price to which juice has now fallen and this downward trend could continue if the coming season produces average crops.

Lime oil has also been in short supply, leading to an increase in the price. Quarterly average prices and the annual range from 1957 to 1966 in the UK market are given in Table 23. Prices here ranged from 60s. to 70s. per lb. c.i.f. and even the current price of about 60s. per lb. is regarded by the users as being too high and, here again, there is the possibility that the major users, (who are in the confectionery and soft drinks trade) will cease to use lime oil in their formulations, and will rely instead on lemon oil and sweet orange oil, which are now available at about 40s. to 45s. and 5s. per lb. respectively.

Lime juice imported into the UK from all countries, including EFTA but excluding Commonwealth countries, attracts an import duty of 18% *ad valorem* if there is more than 20% sweetening matter added. If the juice has less than 20/ sweetening matter the duty is 15% *ad valorem*. Lime oil is duty free from EFTA and Commonwealth sources but attracts a duty of 25% *ad valorem* from all other countries. Thus oil from Mexico bears the duty and therefore sells less competitively on the market than the West Indian oils.

There are no quantitative restrictions on imports of juice and oil nor are there any specific health regulations. However, there are health officials at all ports of entry into the UK authorized to inspect any goods entering the country to ensure they are fit for human consumption. High quality and standards must therefore be maintained. Standards are also laid down for the manufacture in the UK of ready-to-drink soft drinks containing fruit juice.

THE MARKET AND PROSPECTS FOR LIME JUICE AND LIME OIL IN THE UK

The United Kingdom market for citrus juices has grown during the years 1959 to 1965 from 16.6 million gallons in 1959 to 17.8 million gallons in 1965, an increase of 7.5 per cent. over the period of 1.07 per cent per year[15]. Imports of lime juice are not separately recorded in the UK trade returns but current UK demand for lime juice is estimated at between 1¾ million and 2 million gallons. Most of these supplies come from Commonwealth countries, particularly Ghana, Jamaica and Dominica. In this respect, the dominant position of L. Rose & Co. Ltd., has already been mentioned, both as plantation owners and as large importers and users. In 1965, Mexican lime juice was imported into the UK in a comparatively large quantity, 305,000 gallons compared with 43,000 gallons in the previous year and negligible quantities over the four previous years. This sudden rise in imports from Mexico can be attributed to a rise in the demand for lime juice and to the wish of importers and users to seek alternative sources of supply to the traditional West Indies markets.

In the past few years there has been considerably more interest shown in lime juice than ever before. This interest has been stimulated by the sales efforts of L. Rose & Co. Ltd., and there has been a diversification of consumer tastes from the traditional orange flavouring to the use of more lemon and lime flavourings. Another reason for the increase in lime juice consumption is the growing popularity of using lime juice as a mix with alcoholic beverages such as lager and vodka. It is estimated that the use of lime as a mix has created a demand for an extra ½ million gallons. However, the increase in demand is very much the result of public taste, which is notoriously fickle. For example, before World War II grapefruit juice achieved great popularity but now is an extremely poor seller.

In view of this, it is always possible that within the next few years the position could alter in favour of some juice other than lime. One of the factors that might curtail the demand is the high price. Soft drinks of the same general type, such as lime, orange, lemon, grapefruit, should ideally retail at the same price, but at

present lime juice is more expensive than orange and the purchase tax levied in the UK of 16½ per cent. *ad valorem* on soft drinks penalises lime juice still further.

Because of the high price some bottlers are marketing a product containing both lemon and lime juices, probably in equal parts or thereabouts. Should these become established in the popular taste the present demand for lime juice can be expected to decrease since it is unlikely that the rate of growth in the demand for soft drinks will offset this decrease in lime juice usage.

Imports of lime oil into the United Kingdom are shown in Table 24. Annual average imports of lime oil in the period 1962-66 amounted to 150,000 lb. compared with 100,000 lb. in the preceding five-year period, 1957-61. The highest recorded imports in the period under review were 201,000 lb. in 1966. Imports of lime oil in 1967 were 152,000 lb. The most consistent, and usually the largest, supplier of lime oil to the United Kingdom is Jamaica, whose annual exports have averaged 38,000 lb. over the decade 1957 to 1966. Ghana has become increasingly prominent since 1961 as a source of supply and the Windward Islands maintain a fairly consistent performance averaging, for 1957 the 1966, 25,000 lb. a year. United Kingdom firms generally prefer to deal in West Indian and Ghanian oil.

Since 1965 the United States has figured more prominently as a source of supply and, in fact, in 1966, the USA was Britain's largest supplier sending 57,000 lb. This has probably been to make up for the shortage of lime oil from traditional sources experienced in the market during this time and occasioned by reserve stock buying in anticipation of the shortage.

Merchants' views differ on the quality of Mexican oil; some hold that it is similar in quality to the West Indian oil and, at the other extreme, others argue that the methods of expression used in Mexico give it some undesirable characteristics. Judgement of lime oil quality, as for most essential oils, is largely subjective and so the divergence in trade opinion is understandable. The duty of 25% *ad valorem*, together with the recent devaluation of sterling, combine to make Mexican oil expensive compared with the West Indian product and it seems likely that imports will be curtailed in the near future from the high levels of 24,000 lb. and 25,000 lb. recorded in 1965 and 1966.

The United Kingdom has a re-export trade in lime oil (Table 25 in the statistical appendix) which averaged 17,000 lb. per annum in the period 1962-66.

About 95 per cent of the lime oil imported into the United Kingdom is used as a flavouring for food and drinks. Its characteristic sharp, fresh taste makes it popular in sweets and it is added to lime squashes and cordials to give additional tang. No satisfactory substitute has been found for lime oil and although there are synthetics available they are of low quality compared with the natural oil. One of the major uses of lime oil is believed to be as part of the formula for 'cola' drinks but since these formulæ are closely kept secrets, the quantities of lime oil used in this way cannot be ascertained.

It is estimated that the remaining 5 per cent of lime oil imports are used in cosmetics, especially mens' toiletries. This would appear to be a trade very much restricted by the dictates of fashion and conjecture as to the growth or otherwise of this sector of the market would be fruitless.

Subject to lime products not pricing themselves out of the market, the prospect for the next few years appears to be one of limited but sustained overall growth, largely in the soft drinks trade. It is difficult to estimate the rate of growth but it might be in the region of two to three per cent per annum. This estimate is based upon information supplied to TPI and could be confounded by supply difficulties, alterations in domestic taxation levels, failure of advertising campaigns or changes in public taste, or any combination of these factors.

THE MARKET AND PROSPECTS FOR LIME JUICE AND LIME OIL IN THE MAJOR MARKETS OF CONTINENTAL WESTERN EUROPE

Although there are no statistics available of imports of lime juice into European markets nor is it possible to calculate the level of imports from the export figures of the principal producing countries, there are nevertheless reasons for believing that continental western Europe may take increasing quantities of lime juice during the next few years. Rising personal incomes and generally higher standards of living tend to lift fruit juices out of the luxury class of foods, and dietary changes that include more fruit and vegetables in some meals, coupled with the greater availability of the domestic refrigerator, all help to favour higher consumption of citrus juices and there is no reason why lime juice should not have some share in this expansion, especially if it can be accepted as a drink suitable for preceding the consumption of food, like orange juice.

This does not mean that the European market offers easy entry to importers of lime juice. The trade in orange juice is well-established and is growing faster[15] than that of grapefruit or lemon juice and all these have achieved greater acceptance so far than has lime juice.

Nevertheless, the firm of L. Rose & Co. Ltd., particularly, have been active in promoting sales of lime juice in some Continental markets.

The EEC countries are very difficult to break into because France, Italy and Belgium/Luxemburg will not permit the entry of juice preserved by chemical additives. This effectively excludes lime juice marketed by Rose's which has been preserved by SO_2. In the Federal Republic of Germany, all juices are subject to a quality control and the importer is responsible for ensuring that the required standards are met. These regulations as they apply to the various countries are dealt with in greater detail below.

The Scandinavian countries are the ones that have taken most readily to lime juice and the possibilities of developing these markets seem brighter than those of other Western European countries although it has been reported that the former have reached a peak of demand that will probably last for a few years before there is any further increase.

France, Belgium/Luxemburg, Italy

For the sake of good order it must be stated that, since Italy is itself a major supplier of citrus juices, there is no market in the country for the sale of lime juice or lime oil.

No statistics are available of imports of lime juice into France of Belgium/ Luxemburg. L. Rose & Co. Ltd. inform us that it is not possible to produce a satisfactory lime juice cordial that complies with the local food regulations which, as far as these concern additives and preservatives, are based on the standards set out in the FAO *Codex Alimentarius*. In effect, this calls for preservation exclusively by physical means.

There are no entry control regulations for any of these countries but the juice must have undergone a pasteurisation process (high or low, depending on the importer) in the exporting country and the juice must be packed immediately afterwards in sealed cans.

The general rate of customs duty for these countries was, in May 1969, 18.6% *ad valorem*. If the lime juice contained more than 33% added sugar there was an additional levy in France of 17.65% on the duty paid value. If the juice contained 33% added sugar or less, no additional tax was levied. If the juice contained no sugar, there was a straight duty of 19%. In Belgium/Luxemburg, the additional levy on the duty paid value was 14% if the juice is packed in

containers of 3 kg or less, otherwise it was 7%.

No statistics are available on imports of oil of Lime. It is reported[16] that the outlets in France are very limited, the oil being used only in aerated drinks which do not enjoy in France the same popularity as they do in England.

The general duty on lime oil (not terpeneless) in France and Belgium/Luxemburg is 11.06% *ad valorem* with an added value tax of 23.45% in the case of France and 7% in the case of Belgium/Luxemburg.

Germany and the Netherlands

Total sales in these two countries are very small. The flavour of lime is virtually unknown and it is considered that it will be a very long-term task to establish the sale of lime drinks in any quantity. Although the reports we have had from several contacts in these countries are generally of a discouraging nature, there are one or two merchants who think that the consumption of both oil and juice will increase in the course of the next few years. The general consensus of opinion is that lime juice and lime oil are used mainly in the Cola drinks and the two brand leaders in this field, Coca Cola and Pepsi Cola, obtain their raw material from the USA.

In the early part of 1969, offers of cold-pressed lime oil were being made at US $9.95 per lb. and of distilled oil at US $7.75 per lb., both prices net f.o.b. Mexico or Caribbean ports. At these prices business was, at that time, being concluded.

The general tariff for the German Federal Republic was, in May, 1969, 18.6% *ad valorem* if the juice contained 33% added sugar or less. If the sugar content was higher than 33% an additional levy of 11% on the duty paid value was payable. In the case of the Netherlands, the additional levy is 12 per cent.

The general tariff on a lime oil (not terpeneless) is 11.06% *ad valorem* with the additional levy of 11%, effectively reduced to 7% by reason of a refund allowable up to 31st March 1970. The additional tax is also 7% in the case of the Netherlands.

No quantitative restrictions are imposed but, according to German law, all juices are subject to quality control. The importer is responsible if the required standards are not met and so all shipments are examined by an accredited chemist, in the form of sample tests, on behalf of the importer.

Switzerland

Reports from Switzerland indicate that the Swiss consumer hardly knows the flavour of lime and it is only British and American tourists who ask for the juice. Exports from the United Kingdom of cordial are reported to be only a few hundred gallons a year.

There is a small trade in lime oil, mainly to the perfume and cosmetics trade. The firm of Givaudan S/A, the largest essential oil user in Switzerland, uses about 2,000 kg. a year. Another firm buys about 200-300 kg. a year of a special quality cold-pressed lime oil for which they were paying, in the early part of this year, US $11.45 per lb. f.o.b. At the same time, distilled lime oil was US $8.00 per lb. f.o.b.

The tariffs that follow are as at February 1968:

No. 20.07	*General*
Fruit juices, unsweetened	
Other:	
Neither frozen nor concentrated	fr 28.00 per 100 kg
Frozen or concentrated	fr 32.00 per 100 kg
Sweetened:	
In glass bottles of 2 decilitres or less	fr 30.00 per 100 kg
Other	fr 70.00 per 100 kg
No. 33.01	
Essential oils, citrus fruits	fr 9.00 per 100 kg

There are no EFTA reductions.

Scandinavia

L. Rose & Co. Ltd. report that the total usage of lime juice in Scandinavia is, at present, about 160,000 gallons a year. In their opinion, the market has reached its peak and is not likely to show any increase for the next few years. Nevertheless, these countries, particularly Sweden and Denmark, have shown an interest in lime juice that has not been apparent in other parts of Europe and, for this reason alone, they should be viewed as potential markets by would-be suppliers.

Sweden

It has been reported by one firm in Sweden that the total market for lime juice in that country in 1968 was supposed to be about 1 million litres (say 220,000 gallons), all of which would be in carbonated form in bottles of 37 and 75 centilitres. This figure must be contrasted with the much smaller figure reported by L. Rose & Co. Ltd. Unfortunately, there are no published statistics and one has, perforce, to rely on trade estimates. In some cases, the bottles of juice are themselves imported and, in others, the juice is imported in bulk in barrels and bottled under licence.

The Swedish tariff as at January 1967 was:

Fruit juices (including grape and vegetable juices, must whether or not containing added sugar, but unfermented and not containing spirit)

Citrus fruit juices:

Unsweetened, in containers of a gross weight:	*Rate* *
Exceeding 3 kg	15
Not exceeding 3 kg	20(1)
Sweetened	30(1)

* In Swedish Crowns per 100 kgs net weight. No EFTA reductions.

(1) The duty is levied on the net weight of the goods, including the packagings in which such goods are usually sold by retail.

The Swedish market depends largely on the drinking habits of the population and these are generally sophisticated and subject to sudden changes. For instance, when vodka with lime was a popular drink in Sweden, sales of lime juice rocketed and were maintained at a high level for about three years. Then taste shifted to drinks not using lime juice and sales declined.

It is reported that Norway and Denmark follow Sweden in drinking habits.

The following was the Norwegian tariff as of 1st April, 1969:

Citrus fruit juices,

Containing added sugar,	
Other than orange	3 Norwegian Kroner per kg
Not containing added sugar,	
Other than orange	0.60 " " "

No EFTA reductions apply.

It must be noted that all processed fruit products are subject to strict quality control by the Norwegian Government and processors or their agents must submit samples of their products for examination by STATENS KVALITETS-KONTROL VEGETABILSKE KONSERVER, BREIGATEN 10, OSLO, NORWAY. Imports cannot pass through customs unless the laboratory's stamp of approval has been affixed to the invoice. This implies that samples have to be submitted and approved before actual import takes place.

There are no such regulations in Denmark other than the fact that the juice should be pasteurised before leaving the exporter. Large users might be expected to issue directions to exporters for specific processing requirements or for particular additives to be included.

The tariff rates for Denmark as at 1st April 1968 were:

Citrus juices:

Sweetened	14.4% ad. val. (No EFTA reduction)
Unsweetened	Free

Enquiries about lime oil markets in the Scandinavian countries have proved fruitless. If any market does, in fact, exist it must be very small.

The following are the tariffs on lime oil as at 1st April, 1968:

Item 33.01 Essential Oils (terpeneless or not)

Sweden	Free of duty – all countries
Denmark	Free of duty – all countries
Norway	6.4 Norwegian Kroner per kg (No EFTA rebate)

THE WORLD PICTURE FOR LIME JUICE AND LIME OIL

It would appear that the proposed future production of lime juice will be more

than enough to meet the likely demand. It is difficult to arrive at a satisfactory estimate of production because of the lack of statistical data. The following projections have been made by Dr. Gordon K. Maliphant, the Head of Citrus Research at the University of the West Indies, Trinidad, for production in Commonwealth Caribbean countries by 1971.

	Tons
Antigua	Nil
Br. Honduras	8
Dominica	5,100
Granada/Cariacou	1,400
Guyana	3,600
Montserrat	100
St. Kitts	Nil
St. Vincent	3,000
Trinidad/Tobago	2,000
	15,208 Tons

Projections for Jamaica, St. Lucia and Barbados are not available but production in Jamaica in 1965 was 14,300 tons and, in St. Lucia, 121 tons whilst Barbados production in 1966 was 34 tons. Even assuring that production in these three territories remains static at these levels, some 30,000 tons of limes will be produced by 1971. If it is further assumed that 1 ton of limes will give 75 gallons of settled juice, the production for this area will be about 2¼ million gallons. To this must be added African and Mexican production. Ghana can produce upwards of 1¼ million gallons, Nigeria about 15,000 gallons and if Tanzania's plans come to fruition there may be 1 million gallons to be added for that country, making a total of 3½ million gallons. Mexican exports in 1965 amounted to 416,000 gallons so that, at a conservative estimate, world production in 1971 can be considered to be about 4 million gallons of juice.

Estimates of future demand are, if anything, even more difficult to calculate. In 1965, UK imports of juice were of the order of 2 million gallons, those of the USA say, 650,000 gallons and Europe about 200,000 gallons. If we assume a rate of growth in demand of 3 per cent per annum, the total demand from these markets by 1971 will be about 3 million gallons. Thus, even on these rough estimates and bearing in mind local consumption there looks to be every possibility of a surplus of lime juice in the next year or two.

In the case of lime oil, the recorded imports in 1966 into the only two markets of any significance, namely the UK and the USA, were 201,000 lb. and 723,000 lb. respectively making a total of 924,000 lb. Against this Monsieur Cadillat of the Institut Francais de Recherches Fruitieres, Paris, has estimated(17) world production at 550 metric tons (1,212,542 lb.) so production appears to be able to meet reasonable demands.

Assuming the continued overall growth of demand for lime products (there may be short-term variations), the decision of a developing country to enter the field of lime-growing and processing must be influenced by other factors. These are, chiefly, the degree of competition from other supplying countries and the overall position of supply in relation to demand. The number of areas at present going in for lime production has already been pointed out in this report and it is safe to say that, normal conditions prevailing, the supply of lime juice and lime oil is sufficient to meet all demands. Natural phenomena such as tree disease, hurricanes and other adverse climatic conditions can upset this balance but the current situation in for

example, the UK is that the market is being oversupplied and the prices of both juice and oil are depressed. This situation has arisen following good crops in the producing countries, a poor summer in the UK and over-buying by users.

There are, therefore, good reasons for treating with reserve the notion of limes being a crop with a good long-term prospect of profitability. Some of these reasons have been adduced above and another is the fact that it takes 8 to 10 years for lime trees to reach full bearing stage. Thus the decision to plant limes in any area where there are no existing trees should only be taken after the most exhaustive assessment of the issues involved.

REFERENCES

1 Dominica 1963, 1964 and 1965. HM Stationery Office, London.

2 Interim Report, West Indies Census of Agriculture, 1961, Dominica, June, 1965.

3 Private Communication by Mr. M.J. Edmonds, Tropical Products Institute.

4 The West Indian Citrus Industry, Report of Fact Finding Commission. Feb. 1955, HM Stationery Office, No. Col 314.

5 The Essential Oils by E. Guenther, III, D. Van Nostrand Company, Inc., New York, 1949.

6 Jamaica, 1961. HM Stationery Office, London, 1965.

7 Private Communication by Comptroller of Customs & Excise, Guyana.

8 Trinidad and Tobago 1957. HM Stationery Office London, 1961.

9 Private Communication by Mr. J.G. Searle, Managing Director, Trinidad Lime Products Ltd., Trinidad.

10 Montserrat 1963 and 1964. HM Stationery Office, London, 1966.

11 'The Citrus Industry of Mexico' Foreign Agricultural Service. US Dept. of Agric. Sept. 1962.

12 *Ghana Farmer* 1964 8 No. 2.

13 'Visits to the Gambia and Ghana' by W.S.A. Matthews. TPI Report R/20/1967.

14 'Suggested Trends in the Avocado and Lime Industries' by Luther L. Chandler et al. Proceedings of the Florida State Horticultural Society.

15 'The European Market for Citrus Juices' Gatt International Trade Centre, Geneva 1966.

16 Private Communication by P. Vigne of Syndicat National des Fabricants and Importateurs d'Huiles Essentielles and Produits Aromatiques Naturels, 7 Rue Gazan, Grasse (Alpes Maritimes), France.

17 'Consideration sur les Huiles Essentielles d'Agrumes' by Monsieur R.M. Cadillat, Institut Francais de Recherches Fruitieres Outre-Mer, Paris, France – To be published.

Table 1
Lime Juice, Settled
Exports from Dominica

			1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
					(a)	(a)	(a)					
Totals	Gals. '000		326.1	582.5	727.1	443.0	89.0	19.4	20.6	152.9	291.2	177.6
	£ '000		75.0	186.5	243.8	177.3	22.3	6.2	6.3	44.2	85.2	66.5
of which to:												
United Kingdom	Gals. '000		268.3	477.2	614.5	...	...	0.6	–	...	...	...
	£ '000		60.2	149.6	203.7	...	...	0.2	–	...	...	...
Canada	Gals. '000		9.1	20.1	21.6	...	...	6.9	8.8	...	...	...
	£ '000		2.1	7.7	8.3	...	...	2.1	2.4	...	...	...
Other West Indies	Gals. '000		9.3	19.2	18.4	...	...	1.3	–	...	...	...
	£ '000		2.3	6.3	6.1	...	...	0.4	–	...	...	...
United States	Gals. '000		6.5	12.4	13.2	...	...	7.3	7.3	...	...	...
	£ '000		1.9	4.7	5.1	...	...	2.5	2.4	...	...	...
Australia	Gals. '000	(b)	22.5	39.3	...	...	...	–	1.5	...	...	...
	£ '000		5.0	12.9	...	...	...	–	0.5	...	...	...
Unspecified Countries	Gals. '000		10.4	14.3	59.4	...	...	3.3	3.0	...	...	...
	£ '000		3.5	5.3	20.6	...	...	1.0	1.0	...	...	...

... Separate figures not available
– Nil or negligible
(a) Includes all lime-juice
(b) Includes New Zealand
Source: *Annual Overseas Trade Report Treasury Department*

Table 2
Lime Juice, other than Settled
Exports from Dominica

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
				(a)	(a)	(a)					
Top Pulp	Gals. '000	123.0	144.0	...	...	...	87.1	2.4	26.6	103.6	35.0
	£ '000	37.9	57.3	...	...	...	31.3	0.8	7.8	28.7	12.2
Raw	Gals. '000	–	–	...	...	...	3.0	1.8	0.2	9.0	14.8
	£ '000	–	–	...	...	...	0.9	0.6	–	0.3	0.6
Sweetened	Gals. '000	–	–	...	...	...	25.4	22.7	18.0	–	2.8
	£ '000	–	–	...	...	...	9.6	9.9	8.3	–	1.2
Concentrated	Gals. '000	–	–	...	...	...	113.4	85.1	31.7	24.7	74.5
	£ '000	–	–	...	...	...	196.6	133.2	47.2	31.5	98.3
Totals	Gals. '000	123.0	144.0	...	...	...	228.9	112.0	76.5	137.3	127.1
	£ '000	37.9	57.3	...	...	...	238.4	144.5	63.3	60.5	112.3
of which to:											
United Kingdom	Gals. '000	121.0	137.0	...	...	...	200.7	85.1	...	...	...
	£ '000	36.9	54.0	...	...	...	228.0	133.2	...	...	...
South Africa	Gals. '000	–	–	...	...	...	3.0	1.7	...	...	...
	£ '000	–	–	...	...	...	0.9	0.5	...	...	...
Canada	Gals. '000	2.0	1.0	...	...	...	2.1	2.4	...	...	...
	£ '000	0.8	0.6	...	...	...	0.8	0.9	...	...	...
Other West Indies	Gals. '000	–	5.0	...	...	...	1.6	6.7	...	...	...
	£ '000	–	2.3	...	...	...	0.6	2.7	...	...	...
United States	Gals. '000	–	1.0	...	...	...	21.5	16.1	...	...	...
	£ '000	0.2	0.4	...	...	...	8.1	7.2	...	...	...

... Separate figures not available
– Nil or negligible
(a) Included with main category
Source: *Annual Overseas Trade Report, Treasury Department*

Table 3
Lime Oil
Exports from Dominica

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
					(a)	(a)					
Distilled	lb.'000	20	4343	20	27	33	32	35	17	23	33
	£ '000	47.3	111.6	48.6	55.8	79.0	68.3	74.5	36.0	42.4	68.0
Hand-pressed (ecuelled)	lb.'000	1	1	–	–	–	–	–	–	–	–
	£ '000	3.9	2.9	–	–	–	0.1	0.4	–	0.4	–
In solution	lb.'000	–	–	–	–	–	3	–	–	–	–
Totals	lb.'000	21	44	20	27	33	35	35	17	23	33
	£ '000	51.2	114.5	48.6	55.8	79.0	. . .	74.9	36.0	42.8	68.0
of which to:											
United Kingdom	lb.'000	13	38	16	. . .	. . .	29	32	. . .	. . .	. . .
	£ '000	32.1	97.8	38.5	. . .	. . .	62.6	67.6	. . .	. . .	. . .
Australia	lb.'000	6	4	3	. . .	. . .	2	3	. . .	. . .	. . .
	£ '000	13.8	11.3	8.3	. . .	. . .	3.7	7.3	. . .	. . .	. . .
Other countries	lb.'000	2	2	1	. . .	. . .	4	–	. . .	. . .	. . .
	£ '000	5.3	5.4	1.8	. . .	. . .	. . .	–	. . .	. . .	. . .

. . . Separate figures not available
– Nil or negligible
(a) From Annual Reports of the Department of Agriculture
Source: *Annual Overseas Trade Report Treasury Department*

Table 4
Lime Juice
Exports from Jamaica

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals			(a)	(a)						(a)
	Gals. '000	274	379	284	433	473	493	413	483	619
	£ '000	72	109	65	117	125	126	102	130	196
of which to:										
United Kingdom	Gals. '000	268	372	274	429	466	486	405	467	598
	'000	70	107	61	116	123	124	99	126	187
Canada	Gals. '000	5	...	...	2	5	3	1	2	...
	'000	2	...	...	–	1	1	–	1	...
United States	Gals. '000	–	...	...	2	2	4	3	3	...
	£ '000	–	...	...	1	1	1	1	1	...
Australia	Gals. '000	1	...	...	–	–	–	2	10	...
	£ '000	–	...	...	–	–	–	1	2	...
New Zealand	Gals. '000	–	...	...	–	–	–	2	1	...
	£ '000	–	...	...	–	–	–	1	–	...
Unspecified countries	Gals. '000	–	7	10	–	–	–	–	–	21
	'000	–	2	4	–	–	–	–	–	9

... Separate figures not available
– Nil or negligible
(a) From December summaries
Source: *External Trade of Jamaica The Department of Statistics*

Table 5
Lime Oil
Exports from Jamaica

		1957	1958	1959	1960	1961	1962	1963	1964	1965 (a)
Totals	lb. '000	38	51	38	61	52	55	59	45	67
	£ '000	66	98	75	119	97	104	121	98	151
of which to:										
United Kingdom	lb. '000	32	45	29	60	52	51	56	42	67
	£ '000	53	86	54	117	96	96	113	91	151
Canada	lb.'000	4	–	–	1	–	1	1	2	–
	£ '000	6	–	–	2	1	1	3	4	–
Australia	lb.'000	1	–	7	–	–	3	1	1	–
	£ '000	4	–	16	–	–	7	3	3	–
Other countries	lb.'000	1	6	2	–	–	–	1	–	–
	£ '000	3	12	5	–	–	–	2	–	–

– Nil or negligible
(a) Provisional
Source: *External Trade of Jamaica Department of Statistics*

Table 6
Lime Juice, Raw
Exports from Grenada

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals	Gals.'000	3.2	38.5	32.0	76.0	41.9	12.2	2.2	–	3.0
	£ '000	0.2	5.0	4.6	11.4	6.1	1.7	0.3	–	0.5
of which to:										
Dominica	Gals.'000	3.2	38.5	32.0	48.8	40.4	–	–	–	–
	£ '000	0.2	5.0	4.6	7.3	5.9	–	–	–	–
Trinidad		–	–	–	27.2	1.5	12.2	2.2	–	3
		–	–	–	4.1	0.2	1.7	0.3	–	0.5

– Nil or negligible
Source: *Annual Overseas Trade Report Government Printer*

Table 7
Lime Oil
Exports from Grenada

			1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals	lb.	'000	1.4	1.7	0.1	–	1.2	0.8	2.7	2.5	(a) 5.6
of which to:	£	'000	2.7	4.3	0.2	–	2.6	1.6	6.3	6.3	15.3
United Kingdom	lb.	'000	1.2	1.6	–	–	0.7	0.8	2.7	2.5	2.0
	£	'000	2.5	4.1	–	–	1.7	1.6	6.3	6.3	6.2
Dominica	lb.	'000	0.2	0.1	0.1	–	0.5	–	–	–	–
	£	'000	0.2	0.2	0.2	–	0.9	–	–	–	–
Unspecified countries	lb.	'000	–	–	–	–	–	–	–	–	3.6
	£	'000	–	–	–	–	–	–	–	–	9.1

– Nil or negligible
(a) From December summary
Source: *Annual Overseas Trade Report Government Printers*

Table 8
Lime Juice
Exports from Guyana

		1957	1958	1959	1960	1961	1962	1963	1964
Clear, filtered, etc.	Gals.'000	17.2	10.8	14.3	8.3	2.4	0.1	(a)	11.1
	£ '000	4.1	3.2	3.9	2.4	0.7	0.2		2.8
Raw	Gals.'000	–	0.1	0.9	0.1	–	0.2		–
	£ '000	–	0.1	0.3	0.1	–	0.1		–
Concentrated	Gals.'000	–	–	–	–	0.1	–		–
	£ '000	–	–	–	–	–	–		–
Totals	Gals.'000	17.2	10.9	15.2	8.4	2.5	0.3		11.1
of which to	£ '000	4.1	3.3	4.2	2.5	0.7	0.3		2.8
United Kingdom	Gals.'000	8.4	10.0	13.2	7.8	2.3	–		11.1
	£ '000	2.0	2.9	3.5	2.3	0.7	–		2.7
Other West Indies	Gals.'000	–	0.2	0.4	0.2	0.2	0.3		–
	£ '000	–	0.1	0.1	0.1	–	0.3		0.1
United States	Gals.'000	4.8	0.5	1.6	0.4	–	–		–
	£ '000	1.2	0.2	0.5	0.1	–	–		–
New Zealand	Gals.'000	4.0	0.2	–	–	–	–		–
	£ '000	0.9	0.1	–	–	–	–		–

– Nil or negligible
(a) Figures not available
Source: *External Trade Customs and Excise*

Table 9
Lime Oil
Exports from Guyana

		1957	1958	1959	1960	1961	1962	1963	1964
								(a)	
Distilled	lb.'000	0.3	1.4	0.7	0.8	0.3	0.3		5.6
	£ '000	0.7	4.1	1.9	1.9	0.6	0.5		3.0
Hand-pressed (Ecuelled)	lb.'000	–	–	–	–	–	–		1.4
	£ '000	–	–	–	–	–	–		0.5
Totals	lb.'000	0.3	1.4	0.7	0.8	0.3	0.3		7.0
	£ '000	0.7	4.1	1.9	1.9	0.6	0.5		3.5
of which to:									
United Kingdom	lb.'000	–	1.2	0.5	0.8	0.3	0.3		6.4
	£ '000	–	3.4	1.4	1.9	0.6	0.5		2.5
Trinidad and Tobago	lb.'000	–	–	–	–	–	–		0.4
	£ '000	–	–	–	–	–	–		0.8
United States	lb.'000	0.3	–	–	–	–	–		0.2
	£ '000	0.7	–	–	–	–	–		0.2
New Zealand	lb.'000	–	0.2	0.2	–	–	–		–
	£ '000	–	0.7	0.5	–	–	–		–

– Nil or negligible
(a) No figures available
Source: *External Trade Customs and Excise*

Table 10
Lime Oil
Imports into Guyana

		1957	1958	1959	1960	1961	1962	1963	1964
								(a)	
Distilled	lb.'000	–	–	–	. . .	. . .	0.1	. . .	0.1
	£ '000	–	–	–	. . .	. . .	–	. . .	0.1
Hand-pressed (ecuelled)	lb.'000	0.3	0.1	0.6	0.4	1.3	1.9	. . .	1.9
	£ '000	0.8	0.3	2.3	1.5	2.8	4.0	. . .	5.0
Totals	lb.'000	0.3	0.1	0.6	0.4	1.3	2.0	. . .	2.0
	£ '000	0.8	0.3	2.3	1.5	2.8	4.0	. . .	5.1
of which from:									
United Kingdom	lb.'000	–	–	0.6	–	–	–	. . .	0.1
	£ '000	–	–	2.3	–	–	–	. . .	0.1
Dominica	lb.'000	0.3	0.1	–	0.4	–	–	. . .	–
	£ '000	0.8	0.3	–	1.5	0.1	–	. . .	–
Jamaica, etc.	lb.'000	–	–	–	–	–	0.1	. . .	0.1
	£ '000	–	–	–	–	–	–	. . .	0.2
United States	lb.'000	–	–	–	–	1.3	1.9	. . .	1.8
	£ '000	–	–	–	–	2.7	4.0	. . .	4.8

. . . Separate figures not available
– Nil or negligible
(a) No figures available for 1963
Source: *External Trade Department of Customs and Excise*

Table 11
Lime Juice
Exports from Trinidad and Tobago

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Clarified, filtered	Gals.'000	61.2	60.7	51.5	201.0	26.1	90.9	74.6	84.1	46.8
	£ '000	14.2	17.3	12.0	37.3	6.7	29.4	24.8	23.3	16.4
Raw	Gals.'000	12.8	28.3	0.1	6.0	0.1	0.3	0.8	–	–
	£ '000	4.8	11.1	–	1.7	–	0.1	0.3	–	–
Concentrated	Gals.'000	0.1	0.1	0.1	0.3	0.1	–	0.2	–	–
	£ '000	0.2	0.1	0.1	0.3	0.2	–	3.5	–	–
Totals	Gals.'000	74.1	89.1	51.7	207.3	26.3	91.2	75.6	84.1	46.8
	£ '000	19.2	28.5	12.1	39.3	6.9	29.5	28.6	23.3	16.4
of which to:										
United Kingdom	Gals.'000	67.4	84.8	46.5	197.0	19.8	66.8	50.6	68.6	35.6
	£ '000	16.6	26.6	10.6	36.3	4.5	16.4	15.1	18.2	12.1
South Africa	Gals.'000	5.5	2.5	2.5	–	–	–	0.8	–	–
	£ '000	2.2	0.9	0.6	–	–	–	0.3	–	–
Canada	Gals.'000	–	1.6	–	6.0	0.1	3.1	9.5	6.7	5.7
	£ '000	–	0.7	–	2.3	–	1.0	3.7	2.1	2.0
United States	Gals.'000	–	–	2.1	–	6.3	20.7	14.5	8.8	5.5
	£ '000	–	–	0.6	–	2.2	11.9	9.4	3.0	2.3
Other countries and	Gals.'000	1.2	0.2	0.6	1.3	0.1	0.6	0.2	–	–
ships' stores	£ '000	0.4	0.3	0.3	0. 7	0.2	0.2	0.1	–	–

– Nil or negligible
Source: *Overseas Trade Report Central Statistical Department*

Table 12
Lime Oil
Exports from Trinidad and Tobago

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Distilled	lb.'000	6.6	7.7	4.0	12.2	11.7	22.0	5.4	34.4	8.8
	£ '000	13.3	18.6	8.8	28.3	22.4	38.8	12.5	57.9	20.0
Hand-pressed (ecuelled) (a)	lb.'000	–	–	–	–	–	0.5	–	0.6	–
	£ '000	–	–	–	–	–	1.1	–	1.6	–
Totals	lb.'000	6.6	7.7	4.0	12.2	11.7	22.5	5.4	35.0	8.8
of which to:	£ '000	13.3	18.6	8.8	28.3	22.4	39.9	12.5	59.5	20.0
United Kingdom	lb.'000	5.9	2.4	1.1	4.5	7.5	1.6	1.2	1.5	4.2
	£ '000	12.0	5.5	2.0	10.4	14.1	3.6	2.8	4.4	11.9
Bermuda	lb.'000	–	–	–	2.7	–	15.3	–	29.3	2.7
	£ '000	–	–	–	6.0	–	24.5	–	44.7	2.7
Canada	lb.'000	–	4.4	1.6	2.1	3.9	4.9	3.8	2.7	1.9
	£ '000	–	10.6	3.9	5.1	7.8	10.1	8.5	7.1	5.4
Australia	lb.'000	0.5	0.9	1.1	2.2	–	0.2	–	0.4	–
	£ '000	1.0	2.5	2.9	5.3	–	0.6	–	1.0	–
New Zealand	lb.'000	0.2	–	0.2	0.7	0.3	0.3	0.3	1.1	–
	£ '000	0.3	–	–	1.5	0.5	0.8	0.9	2.3	–
Other countries	lb.'000	–	–	–	–	–	0.2	0.1	–	–
	£ '000	–	–	–	–	–	0.3	0.3	–	–

– Nil or negligible
(a) Excludes re-exports of hand-pressed
Source: *Overseas Trade General Statistical Office*

Table 13
Lime Juice Raw
Exports from Montserrat

		1957	1958	1959	1960	1961	1962	1963	1964
Totals	Gals.'000	8.3	17.1	0.4	0.2	6.7	0.3	5.7	14.2
	£ '000	1.9	3.8	0.1	–	2.1	0.2	2.4	4.1
United Kingdom	Gals.'000	–	...	...	–	–	0.2	0.3	6.3
	£ '000	–	...	...	–	–	0.1	0.1	1.7
Canada	Gals.'000	4.5	...	...	–	6.7	–	–	7.5
	£ '000	1.0	...	...	–	2.1	–	–	2.4
Other West Indies	Gals.'000	–	...	...	0.2	–	0.1	5.4	0.4
	£ '000	–	...	...	–	–	0.1	1.6	–
Australia	Gals.'000	1.6	...	...	–	–	–	–	–
	£ '000	0.4	...	...	–	–	–	–	–
New Zealand	Gals.'000	2.2	...	...	–	–	–	–	–
	£ '000	0.5	...	...	–	–	–	–	–
Unspecified countries	Gals.'000	–	...	...	–	–	–	–	–
	£ '000	–	...	...	–	–	–	0.7	–

– Nil or negligible
. . . Separate figures not available
Source: *Report on Imports and Exports Trade Commission, Montserrat*

Table 14
Lime Juice, Raw
Exports from St. Lucia

		1957	1958	1959	1960	1961	(a)
Totals	Gals.'000	5.4	4.4	3.7	–	5.5	
	£ '000	0.9	0.8	0.68	–	1.2	
of which to:							
United Kingdom	Gals.'000	4.0	4.4	3.7	–	–	
	£ '000	0.7	0.8	0.6	–	–	
Canada	Gals.'000	1.4	–	–	–	–	
	£ '000	0.2	–	–	–	–	
Trinidad	Gals.'000	–	–	–	–	5.5	
	£ '000	–	–	–	–	1.2	

– Nil or negligible
(a) No trade after 1961
Source: *Report on Imports and Exports Government Printer*

Table 15
Lime Oil, Hand-pressed (Ecuelled)
Exports from St. Vincent

		1959	1960	1961	1962	1963
Totals	lb.'000	–	–	0.5	–	0.1
	£ '000	0.1	–	0.1	–	0.1
of which to:						
United Kingdom	lb.'000	–	–	0.5	–	0.1
	£ '000	0.1	–	0.1	–	0.1

– Nil or negligible
Source: ***Trade Report Government Printing Office***

Table 16
Lime Juice
Exports from Mexico

		1957	1958	1959	1960	1961	1962	1963	1964	1965
	(a)									
Totals	Gals.'000	222	83	73	20	73	66	120	93	416
	£ '000	134	54	50	8	35	64	99	77	140
of which to:										
France	Gals.'000	31	–	–	–	–	–	–	–	110
	£ '000	6	–	–	–	–	–	–	–	42
German Federal Republic	Gals.'000	4	–	–	–	–	–	–	1	1
	£ '000	4	–	–	–	–	–	–	5	2
Italy	Gals.'000	7	–	–	–	–	–	–	–	–
	£ '000	6	–	–	–	–	–	–	–	–
United Kingdom	Gals.'000	76	48	47	–	1	–	–	43	305
	£ '000	57	39	36	–	1	–	–	44	94
Canada	Gals.'000	23	–	–	–	–	–	–	–	–
	£ '000	14	–	–	–	–	–	–	–	–
United States	Gals.'000	79	35	26	20	72	66	119	49	–
	£ '000	46	15	14	8	34	64	98	28	–
Other countries	Gals.'000	2	–	–	–	–	–	1	–	–
	£ '000	1	–	–	–	–	–	1	–	–

– Nil or negligible
(a) A factor of 0.207 Imp.gals. per keg, was assumed
Source: *Comercio Exterior Direccion General de Estadistica*

Table 17
Lime Oil, in Specified Containers
Exports from Mexico

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals	lb.'000	0.2	3.8	0.9	1.0	9.7	1.5	4.4	5.0	22.0
	£ '000	0.2	2.2	0.9	1.0	11.5	1.6	31.0	56.5	74.0
of which to:										
France	lb.'000	–	–	–	–	–	–	0.7	0.4	3.4
	£ '000	–	–	–	–	–	–	1.2	0.7	6.0
Netherlands	lb.'000	–	1.1	0.9	0.5	–	–	–	–	–
	£ '000	–	1.1	0.9	0.5	–	–	–	–	–
United Kingdom	lb.'000	–	–	–	–	–	–	–	–	0.9
	£ '000	–	–	–	–	–	–	–	–	1.9
Canada	lb.'000	–	–	–	–	–	1.3	–	–	–
	£ '000	–	–	–	–	–	1.4	–	–	–
Chile	lb.'000	–	–	–	–	–	–	1.2	3.3	5.4
	£ '000	–	–	–	–	–	–	25.3	53.3	50.7
El Salvador	lb.'000	–	1.9	–	–	–	–	–	–	–
	£ '000	–	–	0.6	–	–	–	–	–	–
United States	lb.'000	–	0.5	–	0.4	9.7	–	2.3	0.9	12.3
	£ '000	–	0.5	–	0.5	11.5	–	4.3	1.9	15.3
Other countries	lb.'000	0.2	0.3	–	0.1	–	0.2	0.2	0.4	–
	£ '000	0.2	–	–	–	–	0.2	0.2	0.6	0.1

– Nil or negligible
Source: *Comercio Exterior Direccion General de Estadistica*

Table 18
Lime Oil, in Unspecified Containers
Exports from Mexico

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals	lb.'000	442	374	97	142	273	582	559	181	616
	£ '000	410	440	115	164	301	802	957	379	1,326
of which to:										
United Kingdom	lb.'000	27	31	4	10	16	15	14	9	22
	£ '000	27	36	5	12	18	20	25	18	49
Canada	lb.'000	1	3	–	2	1	–	3	6	1
	£ '000	1	3	–	2	1	–	6	12	3
United States	lb.'000	414	340	91	129	254	564	541	163	588
	£ '000	382	400	107	149	280	777	923	342	1,264
Other countries	lb.'000	–	–	2	1	2	3	1	3	5
	£ '000	–	1	3	1	2	5	3	7	10

– Nil or negligible
Source: *Comercio Exterior Direccion General de Estadistica*

Table 19
Lime Juice, Unfermented (a)
Exports from Ghana

		1957	1958	1959	1960	1961	1962	1963	1964	1965
Totals	Gals.'000	224	230	692	799	871	945	766	612	1,076
	£ '000	22	25	71	88	89	127	167	141	691
of which to:										
United Kingdom	Gals.'000	221	211	675	779	871	945	766	612	1,076
	£ '000	22	23	70	87	89	127	167	141	691
South Africa	Gals.'000	–	19	17	20	–	–	–	–	–
	£ '000	–	2	1	1	–	–	–	–	–
Other countries	Gals,'000	31	–	–	–	–	–	–	–	–
	£ '000	–	–	–	–	–	–	–	–	–

– Nil or negligible
(a) From 1961, includes other fruit juices, which are negligible in previous years
Source: *External Trade Office of the Government Statistician*

Table 20
Lime Juice, not Concentrated
Imports into United States

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
									(a)	(a)	(a)
Totals	(Imp.) Gals.'000	146	207	323	395	437	509	413	645	631	530
	£ '000	151	203	333	420	397	529	393	622	544	504
of which from:											
Italy	Gals.'000	10	3	–	–	–	2	7	1	1	1
	£ '000	10	3	–	–	–	–	9	1	1	1
United Kingdom	Gals.'000	112	161	278	372	310	437	300	575	472	246
	£ '000	128	179	310	406	346	493	342	590	492	174
Canada	Gals.'000	–	–	–	–	–	–	–	–	–	38
	£ '000	–	–	–	–	–	–	–	–	–	51
Leeward and Windward Islands	Gals.'000	–	7	3	–	–	–	–	2	2	172
	£ '000	–	3	1	–	–	–	–	–	1	241
Mexico	Gals.'000	15	32	32	20	116	56	99	61	155	64
	£ '000	8	16	18	12	44	22	35	24	49	26
Trinidad and Tobago	Gals.'000	1	1	5	–	10	14	5	–	–	6
	£ '000	–	–	2	–	7	12	4	–	–	8
Other countries	Gals.'000	8	3	5	3	1	–	2	6	1	3
	£ '000	5	2	2	2	–	2	3	7	1	3

– Nil of negligible
(a) Includes concentrated
Source: *Bureau of the Census Report FT 110 and FT 125 Department of Commerce*

Table 21
Lime Juice, Concentrated
Imports into United States

		1957	1958	1959	1960	1961	1962	1963
Totals	Gals.'000	36	8	6	91	25	124	223
	£ '000	22	2	5	78	26	52	70
of which from:								
Italy	Gals.'000	14	–	–	–	–	–	–
	£ '000	16	–	–	–	–	–	–
United Kingdom	Gals.'000	20	7	3	66	18	8	5
	£ '000	5	2	3	73	22	10	6
Mexico	Gals.'000	–	1	2	25	6	116	212
	£ '000	–	–	1	5	3	42	62
Trinidad and Tobago	Gals.'000	–	–	–	–	1	–	6
	£ '000	–	–	–	–	1	–	2
Other countries	Gals.'000	2	–	1	–	–	–	–
	£ '000	1	–	1	–	–	–	–

– Nil or negligible

Note: After 1963 included with unconcentrated juice

Source: *Bureau of the Census Report FT 110 and FT 125 Department of Commerce*

Table 22
Lime Oil
Imports into United States

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Totals	lb.'000	460	394	227	283	456	652	647	307	678	723
	£ '000	681	770	407	509	767	1,140	1,247	671	1,590	1,791
of which from:											
Cuba	lb.'000	5	7	16	19	–	–	–	–	–	–
	£ '000	7	12	25	30	–	–	–	–	–	–
Dominican Republic	lb.'000	3	5	9	8	12	8	9	8	13	12
	£ '000	4	7	15	12	18	13	16	16	27	26
Haiti	lb.'000	29	26	37	42	75	83	85	74	90	104
	£ '000	49	51	65	68	130	141	162	142	201	262
Jamaica	lb.'000	–	–	2	–	–	6	4	5	–	16
	£ '000	–	–	4	–	–	10	7	10	1	49
Mexico	lb.'000	421	354	163	177	367	543	543	213	570	587
	£ '000	619	696	298	324	615	950	1,047	479	1,353	1,440
Trinidad and Tobago	lb.'000	–	–	–	14	–	–	1	2	3	1
	£ '000	–	–	–	29	–	–	2	6	3	2
Other countries	lb.'000	2	2	–	23	2	12	5	5	2	3
	£ '000	2	4	–	46	4	26	13	18	5	12

– Nil of negligible

Source: *Bureau of the Census Reports FT 110 and FT 125 U.S. Department of Commerce*

Table 23
Lime Oil
Quarterly Average Prices, and Annual Range, c.i.f. London

shillings and pence per lb.

		I	II	III	IV	Annual Range	
						Low	High
West Indian	1957	40/2	45/-	50/-	62/4	36/6	65/-
	1958	65/-	60/-	60/-	52/10	50/-	65/-
	1959	54/-	51/4	50/-	49/4	46/-	54/-
	1960	51/4	50/8	51/-	50/6	48/-	54/-
	1961	49/6	48/6	46/8	47/8	45/-	50/6
	1962	48/-	47/4	46/4	47/-	45/-	48/-
	1963	47/8	48/4	50/-	53/4	47/-	56/-
	1964	60/-	60/-	60/-	64/8	60/-	68/-
	1965	67/-	67/-	67/-	67/-	66/-	68/-
	1966	67/-	67/-	67/8	69/4	66/-	70/-
	1967	73/4	76/-	76/-	76/-	70/-	76/-
	1968	76/-	72/6				
Mexican (duty-paid)	1957	40/10	44/-	46/8	56/2	38/6	58/-
	1958	59/4	59/4	59/-	59/-	58/-	60/-
	1959	57/-	54/8	56/8	54/-	50/-	58/-
	1960	54/-	52/-	52/-	52/-	52/-	54/-
	1961	49/8	49/-	49/-	49/-	48/-	52/-
	1962	49/-	49/-	49/-	48/4	45/-	49/-
	1963	47/-	50/4	52/-	52/8	47/-	54/-
	1964	54/-	54/-	54/-	54/-	54/-	54/-
	1965	54/-	54/-	54/-	54/-	54/-	54/-
	1966	70/-	70/-	68/4	65/-	65/-	70/-
	1967	65/-	65/-	65/-	65/-	65/-	65/-
	1968	65/-	68/-				

Source: *Perfumery and Essential Oil Record*

Table 24
Lime Oil
Imports into the United Kingdom

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
												(a)
Totals	lb.'000	93	130	44	97	148	112	149	119	171	201	152
	£ '000	165	273	86	191	256	209	279	241	425	511	421
of which from:												
Ghana	lb.'000	–	3	5	9	23	18	41	21	23	28	35
	£ '000	–	2	4	7	18	23	61	39	48	55	69
Jamaica	lb.'000	21	37	19	43	42	45	50	30	49	49	41
	£ '000	46	101	49	104	98	103	115	75	150	154	138
Mexico	lb.'000	31	22	2	7	16	12	14	5	24	25	16
	£ '000	51	46	5	14	29	23	29	10	59	69	44
United States	lb.'000	17	15	2	–	27	5	3	16	40	57	14
	£ '000	31	32	3	–	48	10	8	38	105	155	39
Windward Islands	lb.'000	12	45	13	26	31	28	24	20	23	30	14
	£ '000	17	75	20	38	43	42	35	28	37	50	39
Other countries	lb.'000	12	8	3	12	9	4	17	27	12	12	32
	£ '000	20	17	5	28	20	8	31	51	25	28	92

– Nil of negligible
(a) Subject to amendment
Source: *The trade of the United Kingdom H.M. Customs and Excise*

Table 25
Lime Oil
Re-exports from the United Kingdom

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
										(a)	(a)
Totals	lb.'000	11	15	13	14	12	12	13	18	16	24
	£ '000	26	41	35	38	29	28	32	46	46	73
France	lb.'000	2	1	1	2	–	–	–	–	3	1
	£ '000	4	3	3	6	–	–	–	–	10	4
German Federal Republic	lb.'000	–	–	1	2	2	2	–	–	–	–
	£ '000	–	–	3	6	4	4	–	–	–	–
South Africa	lb.'000	1	3	2	2	1	3	–	–	4	2
	£ '000	2	8	5	6	2	6	–	–	13	7
United States	lb.'000	–	–	–	–	–	–	–	–	–	16
	£ '000	–	–	–	–	–	–	–	–	–	47
Australia	lb.'000	1	5	4	4	3	–	–	6	4	–
	£ '000	4	13	9	10	6	–	–	16	11	1
New Zealand	lb.'000	1	2	1	1	–	–	–	–	2	3
	£ '000	3	5	3	1	-	-	-	-	5	8
Other countries	lb.'000	6	4	4	3	6	7	13	12	3	2
	£ '000	13	12	12	9	17	18	32	30	7	6

– Nil or negligible
(a) Subject to adjustment

Source: *The Trade of the United Kingdom H.M. Customs and Excise*

Tropical Products Institute

G 47

The market for natural rubber with particular reference to the competitive status of synthetic rubber

Tropical Products Institute Report

47

The market for natural rubber with particular reference to the competitive status of synthetic rubber

C. E. F. Manning

May 1970

Tropical Products Institute 56/62 Gray's Inn Road London WC1

Ministry of Overseas Development

This report was produced by the Tropical Products Institute, a British Government organization which helps developing countries to derive greater benefit from their renewable resources.

It specializes in post-harvest problems and will be pleased to answer requests for information and advice. Reports such as this one are often written as the result of an enquiry.

Requests for further information should be addressed to:

The Director,
Tropical Products Institute,
56/62 Gray's Inn Road,
London W.C 1

ACKNOWLEDGEMENTS

The Institute acknowledges with gratitude the assistance given by users of rubber and members of the trade in the preparation of this report.

Contents

Summary

Introduction

Nearly all the natural rubber on the market is the product of the tree *Hevea brasiliensis* L. The rubber is obtained from the tree as a colloidal aqueous dispersion known as latex. A small proportion of the rubber produced is sold as concentrated latex; more usually the latex is coagulated and shipped as sheet rubber.

In recent years there have been several major developments in the production and presentation of natural rubber:

(a) Plantations have been replanted with high yielding trees on an increasing scale.
(b) Plant hormones have been applied to trees as yield stimulants.
(c) Processing methods have been developed which produce a 'crumb' rubber in solid bale form.

The new processing methods are particularly suited to production of the newly developed types of rubber; controlled viscosity (CV) rubber, low viscosity (LV) rubber and oil extended natural rubber (OENR). These methods are also suited in varying degrees to the processing of both good and scrap raw rubber.

The new types of rubber are packed in smaller bales than the old types and are graded by technical specification.

Synthetic rubbers may be classified as general purpose rubbers, of which the most common is styrene butadiene rubber, and special purpose rubbers.

The synthetic rubber which reproduces the properties and characteristics of natural rubber most closely is cis-polyisoprene, one of the class of synthetic rubbers known as stereoregular rubbers.

Synthetic and natural rubbers are known as elastomers.

Production

The world acreage under rubber is increasing and total world production of natural rubber increased from 1,990,000 tons in 1960 to a preliminary figure of 2,500,000 tons in 1967. The main producers, in decreasing order of importance, are West Malaysia, Indonesia, Thailand and Ceylon.

Production of synthetic rubber has exceeded that of natural rubber since 1962. Known world production, excluding that of the USSR and mainland China, rose from 1,984,000 tons in 1960 to a preliminary figure of 4,310,000 tons in 1967. The main producers are the United States, the USSR, Japan, Canada, the United Kingdom and the member countries of the European Economic

Community (EEC). In recent years there has been a marked trend towards overproduction.

Consumption

World consumption of elastomers increased from an average 3,340,000 tons per annum in the period 1955–57 to 6,606,000 tons in 1966. Consumption of both natural rubber and synthetic rubber increased but natural rubber's share of total elastomer consumption fell from 58 per cent in the period 1955–57 to 39 per cent in 1966.

The main consuming countries, in decreasing order of importance are the United States, the USSR, Japan, the United Kingdom, the member countries of the EEC, and Canada.

The main consuming industry is the tyre industry. In the United States the tyre industry used 65 per cent of all natural rubber consumed in the US between 1953 and 1964. In 1965 and 1966 the proportion rose to 70 per cent.

Synthetic rubber has been used on an increasing scale in both the tyre and non-tyre industries. In the United States natural rubber usage in the tyre industry fell from an average of 44 per cent in the period 1953–55 to around 27 per cent in the period 1961 to 1966. In the non-tyre industry the proportion fell from 42 per cent in the period 1953–55 to 20 per cent in 1966.

International trade

Exports

World exports of natural rubber increased from an average 1,891,000 tons per annum in the period 1955–59 to 2,277,000 tons in 1966. The main exporting countries, in decreasing order of importance, are Malaysia, Indonesia, Thailand, and Ceylon.

World exports of synthetic rubber rose from an average 347,000 tons per annum in the period 1955–59 to 891,000 tons in 1965. In 1966 the major exporting countries were the United States, Canada, the member countries of the EEC, the United Kingdom, Japan and the German Democratic Republic.

Imports

In 1966 the major importers of natural rubber were the United States, Japan, the United Kingdom, China, the German Federal Republic and France. In 1965 the USSR was second in importance only to the United States.

In 1966 the main importers of synthetic rubber were France, the German Federal Republic, Italy, the United Kingdom, the USSR, Japan and Canada. Imports were fairly steady or increased steadily over the period 1960–66 in all these countries.

Stocks

World stocks of natural rubber increased from 688,000 tons in 1959 to 857,000 tons in 1966 (excluding stocks held in Government stockpiles, in the USSR and in mainland China). Production of natural rubber has tended at certain periods to fall short of consumption, but the deficit has been more than made up in recent years by releases from US Government stockpiles. Since

the 1st July 1967, these have been made at a rate of 70,000 tons per annum, but in February 1969, the US General Services Administration decided to stop rubber sales from the stockpile. This resulted in an immediate boost to prices and RSS No. 1 on the London market reached its highest level for six years.

World stocks of synthetic rubber increased from 335,000 tons in 1959 to 677,000 tons in 1966. In 1966 the major stockholders, in decreasing order of importance, were the United States, France, Japan, Canada, and the United Kingdom.

Prices

Natural rubber prices have fallen almost continuously in recent years from a price of 108·1 Malaysian cents/lb f.o.b. Singapore for RSS1 in 1960 to 45·4 cents/lb in February 1968. Prices began to recover in March and were quoted at 57·25 cents/lb in August 1968. Prices of other grades of rubber and rubber from other sources moved in much the same way. Following the decision of the US/GSA to stop sales from the stockpile, the price in February 1969 for RSS1 rose to 77 cents/lb.

The general decline is attributable to several main factors:

(a) Increasing production in Malaysia as a result of the replanting scheme.
(b) Heavy releases in the past from US government stockpiles.
(c) Spasmodic buying performances by some of the centrally planned economies.
(d) Lower levels of economic activity in most developed countries and hence lower demand.
(e) Competition from synthetic rubber.

In the long run the price of *cis*-polyisoprene is likely to set a price-ceiling for natural rubber. In Malaysia it is believed that a repetition of the price decline of recent years can be avoided, but that the long-term price trend of natural rubber will not be favourable to producers. The US/GSA decision, though welcome, is regarded merely as a temporary palliative and the size of the stockpile is still considered, in many quarters, to be a threat to the market.

Future prospects

It has been forecast that world production of natural rubber could increase by 3 per cent in 1968 and is likely to continue increasing into the 1970's as replanted trees reach maturity.

Supplies of synthetic rubber could increase by up to 10 per cent in 1968 and by much more in the 1970's as new producing countries enter the market.

Demand for elastomers is expected to continue its upward trend, the demand for synthetic rubber increasing more rapidly than that for natural rubber.

A large part of the increased demand for natural rubber is expected to come from increases in tyre production and from the larger quantity of natural rubber used per tyre in the newer types of tyres.

It is generally felt that production of natural rubber will increase more rapidly than consumption in the near future and that stocks will therefore accumulate.

The future for natural rubber seems fairly promising provided it can remain competitive with synthetic rubber. This could be achieved by lowering production costs and by presenting natural rubber in a form comparable to that of synthetic rubber. Both these developments are currently taking place.

The market for natural rubber with particular reference to the competitive status of natural rubber

INTRODUCTION

World demand for elastomers is satisfied by natural rubber and synthetic rubber.

Over the period 1955 to 1967 production of both natural and synthetic rubbers increased. Consumption of synthetic rubber increased over the period while consumption of natural rubber increased to 1966 but fell somewhat in 1967. Table 1 shows world production and consumption of natural and synthetic rubbers in recent years.

Table 1
World rubber situation
('000 tons)

		1955–57	1962–64	1965	1966	1967 Prelim.
Production	NR	1,936	2,175	2,380	2,438	2,494
	SR	1,454(1)	3,121(1)	3,765(1)	4,157(1)	4,310(1)
Consumption	NR	1,920	2,273	2,421	2,571	2,499
	SR	1,420	3,027	3,694	4,035	4,168

(1) Estimate.
Source: Derived from *FAO Commodity Review*, 1968.

It can be seen that production of natural rubber tended to fall short of consumption whereas production of synthetic rubber tended to exceed consumption.

Production of synthetic rubber caught up with that of natural rubber in 1961 and has since exceeded it. Since 1963 consumption of synthetic rubber has exceeded that of natural rubber.

The share of the world elastomers market held by natural rubber fell from 58 per cent in the period 1955–57 to 37 per cent in 1967.

Natural rubber

Virtually all the natural rubber used in the world to-day is obtained from the tree *Hevea brasiliensis* L. (Willd. ex A. Juss.) Muell.-Arg. This tree, indigenous to Brazil, was introduced into Asia towards the end of the 19th century. Although there is some production of raw natural rubber in South America that sells in insignificant quantities in some markets, production is now based mainly in Asia, particularly in Malaysia and Indonesia. Production in Asia is almost entirely from plantation rubber.

Rubber is produced in the bark of *Hevea*. The rubber is contained in latex which is obtained by cutting the bark, so rupturing the latex vessels and enabling the latex to flow.

In March the leaves fall from the trees and the flow of latex is reduced. This process is known as 'Wintering' and can entail production cuts of up to 30 per cent.

The rubber content of *Hevea* latex increases with the age of the tree, which, if a high yielding variety, will take about 12 years to reach maturity. It also varies with season. Fresh latex consists of around 33 per cent rubber, 3 per cent non-rubber solids and 64 per cent water. Malaysian rubber has a mean dry rubber content (DRC) of 33–34 per cent.

Hevea rubber contains over 90 per cent of rubber hydrocarbon, quantities of sugars, inorganic compounds, resins and traces of other organic compounds. The resilience and elasticity of natural rubber are due to the rubber hydrocarbon, which is polyisoprene. The non-rubber constituents of natural rubber contribute to the coagulation, preservation and vulcanization of the rubber.

Latex obtained from the tree may either be concentrated by removing the water and sold as latex concentrate, or coagulated by the addition of a chemical and made into dry sheet rubber. (Further methods of presentation have recently been introduced and are considered in greater detail below.)

From Malaysia, approximately 85 per cent of the latex produced is shipped as dry rubber. The remaining 15 per cent is shipped as latex concentrate and constitutes the main world supply of latex concentrate. (No producers in Malaysia produce latex only, but change to production of sheet rubber if the premium which latex commands over sheet falls too low.)

Recent years have seen several major developments in the production and presentation of natural rubber:

(a) Plantations have been replanted on an increasing scale with high yielding trees. Some of the most recent plantings are of clones, that is, the selected progeny of a single parent, which have proved capable, on a trial basis, of yields of 3,000 lb. or more per acre at maturity.

(b) The application of plant hormones such as 2:4-D or 2:4:5-T[1] as yield stimulants has led to increases in production from mature trees of up to 20 per cent.

(c) Various processing developments have occurred notably the 'comminution' process, the 'extruder mincing/pelletization' process and the 'Heveacrumb' process. These all produce, by various means, a granulated rubber which is shipped in solid bales. They are all particularly suited to the processing of the scrap rubber which constitutes 15 per cent of the production of most estates. Scrap rubber is in the form of cup coagulum, that is, the rubber left in the collecting cups, and tree lace, which is the coagulated rubber collected daily from the tapping cuts. The new methods can process both good rubber and scrap rubber to produce an extremely acceptable end product. They are also particularly suited to the production of CV and OE natural rubber (see below).

Table 2 shows the residual dirt content of rubber processed by each of these new processes. The starting material in each case was cup lump rubber with a 1 per cent dirt content.

---

(1) 2:4-D 2,4 dichlorophenoxy acetic acid
2:4:5-T 2,4,5 trichlorophenoxy acetic acid

Table 2
Residual dirt content

Process	%
Comminution	0·05
Pelletization	0·05
Heveacrumb	0·02

The increasing importance of these new methods of production is shown in Table 3 which gives estimated Malaysian production in recent years.

Table 3
Estimated Malaysian production by new processes
('000 tons)

	Total	of which Heveacrumb
1963	0·1	—
1964	1·2	—
1965	5·7	0·4
1966	17·9	6·1
1967	33·3	18·3
1968	112·0	93·5

Source: *FAO Commodity Review*, 1968.

The Rubber Research Institute of Malaysia, who developed the Heveacrumb process, expects that 100,000 tons per annum will be produced by this process in Malaysia by the end of 1969. It is understood that Indonesian producers are hoping to adopt crumb rubber processing by one or more of the possible methods by early 1970.

Sheet rubber hardens during storage making it more difficult to store and use. Constant viscosity rubber is produced by the addition before coagulation of small quantities of hydroxylamine hydrochloride. The produce is known as constant or controlled viscosity (CV) rubber. In early 1968 all CV Heveacrumb produced was exported to the United States.

It is desirable that rubber should have a low, as well as constant, viscosity. Rubber from some trees has too high a viscosity for easy processing. This can be lowered by the addition of up to 4 per cent of oil, the viscosity then being fixed by the addition of hydroxylamine. The cost of these additives for fixing low viscosity (LV) rubber is said to be offset by the gains from the simpler processing it makes possible.

It has now been found practicable to extend natural rubber with mineral oil in proportions of up to 30 per cent without seriously affecting the properties of the rubber. By making the rubber cheaper this makes it more competitive with the oil-extended synthetic rubbers. It has also been found that oil-extended natural rubber (OENR) can be blended with a synthetic rubber, *cis*-polybutadiene, to form a compound which is eminently suitable for car-tyre treads.

The new methods of rubber production give a solid bale of rubber rather than a sheet. When small bales of natural rubber first appeared the synthetic rubber bale size of 28" x 14" x 6" was copied. The Rubber Research Institute of Malaysia has now developed a bale 22½" x 15" x 7" weighing 75 lb which must be wrapped in polythene film of specified thickness and which conforms to the ISO (International Standards Organization) pallet sizes. These bales of rubber are sold as Standard Malaysian Rubber (SMR). Most SMR is of crumb type but there is a certain amount of SMR sheet and crepe on the market.

Baled rubber has to be graded by technical specifications; the sheet rubber classifications, based on appearance, are not applicable to solid rubber. SMR specifications and International descriptions of ribbed smoked sheet (RSS) rubber are given in the Appendix.

The Rubber Research Institute intends that SMR technical specifications will eventually replace the RSS classification. The SMR scheme started in 1965, with 1966 being the first complete year of operation. Around 8,000 tons of SMR were exported from Malaysia in 1966. Exports rose to nearly 24,000 tons in 1967 and it has been estimated[1] that over 100,000 tons will be exported in 1968 and possibly 250,000 tons in 1969. If achieved, the 1969 figure would represent 25 per cent of total Malaysian production.

Synthetic rubber

There are many types of synthetic rubber, all of which are competitive, at least to some extent, with natural rubber.

Synthetic rubbers may be broadly classified as general purpose rubbers and special purpose rubbers. General purpose rubbers include styrene-butadiene rubber (SBR), polybutadiene, polyisoprene and ethylene-propylene copolymers. The special purpose rubbers include neoprene rubbers, nitrile rubbers and butyl rubbers.

SBR is not only the synthetic rubber produced in the largest quantities, it is also the cheapest. It is less resilient than natural rubber and more prone to heat accumulation when subjected to continually changing stresses. (High hysteresis.) For this reason SBR is not suitable for use in large or heavy duty tyres. However, SBR plays a large part in the manufacture of passenger-car tyre treads; oil-extended SBR is used, in conjunction with varying amounts of polybutadiene, less where adhesion on wet roads has priority and more where durability is of greater importance.

Polybutadiene is now being used to some extent in large tyre treads also.

Polyurethane rubbers have been used very successfully in the somewhat limited sphere of solid tyres because tyres made of this material have a particularly long life. Polyurethane rubbers are also used in engineering components and in footwear.

Polyisoprene exhibits properties most similar to those of natural rubber, synthetic *cis*-1,4-polyisoprene being sometimes known as 'synthetic natural rubber'. This rubber is produced on a small but growing scale and is likely to present the greatest threat to natural rubber in the long run, particularly in those end uses in which natural rubber has previously been thought irreplaceable.

Of the special purpose rubbers, polychloroprene (neoprene) and nitrile rubbers are the main oil resistant synthetic rubbers, and are used in hoses, for window gaskets and for similar purposes. Butyl rubbers are highly impermeable to gas and are used mainly for car inner tubes. (Approximately 50 per cent of US production of butyl rubber is used in tyres and tyre products[2].) Chlorinated butyl rubber is now the main material used for tubeless tyre interliners. Butyl rubbers are also resistant to sunlight and weathering and are used increasingly for roofing and reservoir sheeting.

'Thermoplastic' synthetic rubbers have been developed in which the molecular

---

(1) Natural Rubber Producers Research Association (NRPRA) Annual Report, June 1968.

(2) *Oil Paint and Drug Reporter* 6.5.68.

crosslinks break on heating and reform on cooling, so enabling articles to be shaped without vulcanization.

Synthetic latex is used increasingly in carpet backing, particularly because it requires little compounding and no vulcanizing.

Uses of rubber

The main market for all elastomers is the tyre industry. Other important end uses include footwear, belting, electrical insulation, flooring materials, surgical goods and foam rubber products.

The rubber used in different types of tyre tread varies according to the type of tyre and also with the country of manufacture. Generally speaking, natural rubber is the preferred choice for heavy-duty and large truck tyres while oil-extended synthetic rubbers are widely used in the treads of passenger car tyres. Light truck tyres are an intermediate case although there is a current tendency to use less natural rubber in these tyres. This trend may be off-set, however, by the development of oil-extended natural rubber.

Table 4 shows the composition of the average American passenger car tyre from which the dominant position of synthetic rubber in this field may be seen.

Table 4
Typical passenger car tyre constitution in USA

	lb.	%
Synthetic rubber	7·5	34·0
Natural rubber	2·5	11·3
Carbon black	6·0	27·2
Chemicals	4·0	18·1
Fabric	1·5	7·2
Steel	0·5	2·2
Totals:	22·0	100·0

Source: *Progress of Rubber Technology*, The Institute of the Rubber Industry, 1967, **31**, 54.

Natural rubber finds many uses in engineering. In recent years it has been developed for use in hydrolastic suspensions, locomotive drive couplings, dock fenders, gaskets and bridge bearings. Natural rubber is used to an increasing extent to replace steel springs.

Rubber latex is used for making dipped goods such as toy balloons, household gloves and similar products. Latex has also found an important use as a backing compound for tufted carpets which are tending to replace traditional woven carpets in many countries.

A short comparison of natural and synthetic rubbers

Sheet natural rubber has the comparative disadvantage that it often needs guillotining, further cleaning, and plasticizing before it enters the mixer where the filler is added. (The filler is the inert compound such as carbon black which is added to increase bulk and, in some cases, to strengthen the rubber.) Both synthetic polyisoprene and the newly-developed bales of natural rubber in crumb form (e.g. Heveacrumb CV) have the advantage that they can be put straight into the mixer. The supremacy of synthetic rubber as far as processing economies are concerned is, therefore, no longer complete.

Study of the comparative properties of products made from natural and synthetic rubber shows that natural rubber products are better in all those properties which stem from natural rubber's superior ability to crystallize when stretched, e.g. abrasion under severe conditions and tear resistance at high temperatures. Natural rubber is somewhat faster curing and has better resistance to age under some conditions. Both these attributes derive from the non-rubber content of natural rubber.

In the past the main reasons for the use of synthetic rather than natural rubber were its more predictable availability and lower price. When polyisoprene was developed, in addition to certain intrinsic advantages, it appeared to duplicate the properties of natural rubber so closely that it was viewed as a serious and immediate threat to the natural rubber industry.

However, developments in the processing and presentation of natural rubber, which are being made on an increasing scale, are again making natural rubber more competitive with synthetic rubber. It appears that natural rubber will continue to be used in many specialist uses where cost is not the over-riding factor. This would appear to be borne out by the statistics shown in Table 1 and considered in detail below where it may be seen that, although natural rubber's share of the elastomer market fell over the period considered, production and, until 1966, consumption of both natural and synthetic rubbers increased.

PRODUCTION

Natural rubber

Available statistics show that the area under rubber is expanding in most producing countries. Total known acreage increased from around 8 million acres in the period 1955–59 to 12 million acres in 1960 and 14 million acres in 1965. The largest areas were Indonesia, West Malaysia, Thailand and Ceylon. Table 5 gives a breakdown by country of the total acreage under natural rubber in several selected years.

Table 5
Area under rubber
(Percentage of total known area)

	1955–59 Average	1960	1965
West Malaysia	46	32	31
Indonesia	16	38	36
Thailand	10	10	13
Ceylon	9	6	4
Other countries	19	14	16

Source: Derived from *Plantation Crops*, Commonwealth Secretariat, No. 11, 1967.

Table 6 shows the most recent percentage breakdown of the above areas by types of cultivation. For this purpose a smallholding is usually taken to be less than 100 acres.

It may be seen that the greater part of the acreage under rubber is in the form of smallholdings.

There is a general trend towards replanting with high-yielding clones. In West Malaysia it is estimated that around 80 per cent of the estates and 40 per cent of the smallholdings have been replanted with high-yield clones.

Table 6
Area under Rubber
(Percentage breakdown by type of cultivation)

Territory	End of	Estates	Small-holding	High Yield Clones	Low Yield Clones
West Malaysia	1965	44	56	64	36
Indonesia	1961	28	72	n.a.	n.a.
Thailand	1965	—	100(1)	27	73
Ceylon	1965	50(1)	50(1)	57	43

n.a.: not available.
(1) Estimate.
Source: Derived from *Plantation Crops*, Commonwealth Secretariat, No. 11, 1967.

The average yield per acre on estates in West Malaysia increased from 400 lb in 1955 to more than 850 lb in 1965. Research into higher-yield clones continues and is financed by a cesse on exports. It is expected[1] that all pre-1940 estate rubber trees will have been replanted with high-yield material by 1977.

Statistical appendix 1 shows the quantities of natural rubber produced in the principal producing countries. Total world production increased from 1,990,000 tons in 1960 to 2,400,000 tons in 1966 and to 2,500,000 tons in 1967[2].

Malaysia (including Singapore) is the world's largest producer of natural rubber. Production increased steadily from 780,000 tons in 1960 to 988,000 tons in 1966. Most of this production came from West Malaysia and Singapore which together produced 708,000 tons in 1960 and 928,000 tons in 1966. Production in 1967 has been estimated at 1,026,000 tons of which 953,000 tons will come from West Malaysia. The increase was the result of two separate but complementary actions: (1) replanting with high yield clones as mentioned above and (2) the planting of large areas of virgin land with rubber. By 1968 the Malaysian Federal Land Development Authority had planted 183,000 acres with rubber and oil palm, of which 125,150 acres were rubber. However, in 1968 it was decided to cut down on rubber planting and to plant oil palm whenever possible.

Indonesia is the second largest producer of natural rubber. Production rose from 610,000 tons in 1960 to an estimated 700,000 tons in 1966.

Production in Thailand rose from 168,000 tons in 1960 to 218,000 tons in 1964 but fell to 204,000 tons in 1966.

In Ceylon the replanting scheme instituted in 1953 led to an increase in production from 97,000 tons in 1960 to 129,000 tons in 1966 despite a fall in total acreage of around 100,000 acres since 1964 and a fall in the rate of replanting.

Countries, other than the major producers, which are known to be growing rubber include Brazil, Brunei, Burma, Cambodia, Cameroun, Congo (Kinshasa), Ghana, India, Liberia, Nigeria, Papua, and Vietnam. Output fell in 1967 in Brazil, Nigeria and Vietnam but rose in India and Liberia.

Synthetic rubber

Appendix 2 shows world production of synthetic rubber. Statistics of production in the USSR and mainland China are not available.

(1) *The Public Ledger*, 8.2.68

(2) Preliminary figure quoted in *FAO Commodity Review*, 1968

In 1960 and 1961 total production of synthetic rubber was approximately equal to production of natural rubber but has exceeded production of natural rubber since 1962. In 1962, 2,361,000 tons of synthetic rubber were produced compared with 2,130,000 tons of natural rubber. By 1966, production of synthetic rubber had increased to 3,500,000 tons while production of natural rubber had increased to 2,400,000 tons. A preliminary figure of production of synthetic rubber in 1967 is 4,310,000 tons. (This includes an estimated 640,000 tons from the USSR.)

The major producer is the United States where production increased from an average 1,121,000 tons per annum in the period 1955–59 to 1,970,000 tons in 1966. In 1966 the US produced 56 per cent of all the synthetic rubber produced outside the USSR and China. Production is understood to have fallen somewhat in 1967 owing to prolonged strikes in the rubber-manufacturing industry.

Prior to 1966, Canada was the second largest producer for which statistics exist, production increasing from an average 119,000 tons per annum in the period 1955–59 to 203,000 tons in 1965 and falling to 200,000 tons in 1966. It is understood that production fell again slightly in 1967.

In 1966, Japan displaced Canada as to the second largest producer having expanded production from 18,000 tons in 1960 to 228,000 tons in 1966. Production rose rapidly by a further 50,000 tons in 1967.

Other large producers of synthetic rubber include the member countries of the European Economic Community, the United Kingdom, and the German Democratic Republic. In 1967 production in France increased by about 25,000 tons, but production fell in the German Federal Republic as a result of a general slowing down in the rate of economic growth. Production in the United Kingdom has risen steadily from an annual average of 14,000 tons in the years 1955–59 to 90,000 tons in 1960 and thereafter increasing annually up to 191,000 tons in 1966. The German Democratic Republic also recorded steady production increases which reached 100,000 tons in 1966. Production increased rapidly in India and Argentina although total production in these countries is, as yet, small.

It has been estimated(1) that production in the USSR was around 500,000 tons in 1965 which, if correct, would make the USSR the second major world producer of synthetic rubber.

In recent years production of synthetic rubber has been marked by over production and by a growing overproductive capacity. It has been estimated(2) that, in 1967, the UK synthetic rubber industry was operating at around 80 per cent capacity, the US at 76 per cent, the French at 70 per cent and the industry in the German Federal Republic at 63 per cent. The cuts in production which occurred in many countries in 1967 were, generally speaking, cuts in the production of SBR(3). Output of other synthetic rubbers continued to rise. In the United States production of polybutadiene rose by 8 per cent and production of other synthetic types by more than 20 per cent.

CONSUMPTION

Total world consumption of elastomers (see Table 1) increased from an average 3,340,000 tons per annum in the period 1955–57 to 6,606,000 tons in 1966, an increase of 98 per cent.

---

(1) *Plantation Crops*, Commonwealth secretariat. No. 11. 1968

(2) *Financial Times* 29.7.68.

(3) *FAO Commodity Review*, 1968

Consumption of both natural and synthetic rubber increased over the period. Annual consumption of natural rubber increased from an average 1,920,000 tons in the period 1955–57 to 2,571,000 tons in 1966, an increase of 34 per cent. Preliminary figures for 1967 show a fall to 2,499,000 tons.(1) Consumption of synthetic rubber rose from an average 1,420,000 tons per annum in the period 1955–57 to 4,035,000 tons in 1966, an increase of 184 per cent. Preliminary figures for 1967 show a further rise to 4,168,000 tons. Thus, in 1966, 39 per cent of total consumption was of natural rubber compared with 58 per cent in the period 1955–57.

In 1966 the major consuming countries in decreasing order of importance were the United States, the USSR, Japan, the United Kingdom, the German Federal Republic, France, Italy and Canada.

Appendices 3 and 4 give consumption of natural and synthetic rubbers in the main consuming countries.

The United States

Total consumption of elastomers rose from an average 1,485,000 tons per annum in the period 1955–59 to 2,222,000 tons in 1966, an increase of 50 per cent. Preliminary figures for 1967 show a fall to 2,162,000 tons. This fall was caused mainly by a three-month strike in the rubber manufacturing industry. Consumption of natural rubber fell from an average 555,000 tons per annum in the period 1955–59 to 427,000 tons in 1961 but then recovered to 550,000 tons in 1966. Preliminary 1967 figures show a fall to 506,000 tons. Consumption of synthetic rubber increased from an average 930,000 tons per annum in the period 1955–59 to 1,672,000 tons in 1966 and then fell to a preliminary figure of 1,656,000 tons in 1967.

The USSR

Estimated total elastomer consumption rose from an average 400,000 tons per annum in the period 1955–59 to 886,000 tons in 1966 an increase of 121 per cent. Consumption of natural rubber, taken as net imports, rose from an average 140,000 tons per annum in the period 1955–59 to 330,000 tons in 1961 and 1962, fell to 160,000 tons in 1964 and rose again to 276,000 tons in 1966. It is reported that consumption fell in 1967, probably as a result of substitution with synthetic rubber. Estimated consumption of synthetic rubber rose from an average 260,000 tons per annum in the period 1955–59 to 600,000 tons in 1964. Estimated consumption remained at this level until 1966.

Japan

Total consumption of elastomers increased steadily from an average 138,000 tons per annum in the period 1955–59 to 432,000 tons in 1966, an increase of 213 per cent. Consumption of natural rubber increased from an average 123,000 tons per annum in the period 1955–59 to 213,000 tons in 1966. It is reported that consumption continued to increase in 1967. Consumption of synthetic rubber increased rapidly from an average 15,000 tons per annum in the period 1955–59 to 219,000 tons in 1966.

The United Kingdom

Total consumption of elastomers increased from an average 254,000 tons per annum in the period 1955–59 to 371,000 tons in 1966, an increase of 46 per

---

(1) *FAO Commodity Review*, 1968

cent. Consumption of natural rubber decreased from an average 201,000 tons per annum in the period 1955–59 to 164,000 tons in 1962. Consumption then increased to 181,000 tons in 1966 but fell again in 1967. Consumption of synthetic rubber increased from an average 53,000 tons per annum in the period 1955–59 to 190,000 tons in 1966.

German Federal Republic

Total consumption of elastomers increased from an average 185,000 tons per annum in the period 1955–59 to 364,000 tons in 1966, an increase of 97 per cent. Consumption of natural rubber increased from an average 138,000 tons per annum in the period 1955–59 to 155,000 tons in 1966, but is reported to have fallen in 1967 because of the lower output of automobiles which resulted from the slowing down of economic growth. Consumption of synthetic rubber increased from an average 47,000 tons per annum in the period 1955–59 to 209,000 tons in 1966.

France

Total consumption of elastomers increased from an average 179,000 tons per annum in the period 1955–59 to 287,000 tons in 1966, an increase of 60 per cent. Consumption of natural rubber averaged 135,000 tons per annum in the period 1955–59 but was steady about 125,000 tons in the period 1960–66. Consumption of synthetic rubber increased from an average 44,000 tons per annum in the period 1955–59 to 165,000 tons in 1966.

Italy

Total consumption of elastomers rose from an average 78,000 tons per annum in the period 1955–59 to an estimated 217,000 tons in 1966, an increase of 178 per cent. Consumption of natural rubber increased from an average 56,000 tons per annum in the period 1955–59 to an estimated 90,000 tons in 1966. It is reported that this increase continued in 1967. Consumption of synthetic rubber increased from an average 22,000 tons per annum in the period 1955–59 to an estimated 127,000 tons in 1966.

Canada

Total consumption of elastomers rose from an average 90,000 tons per annum in the period 1955–59 to 154,000 tons in 1966, an increase of 71 per cent. Consumption of natural rubber fell from an average 42,000 tons per annum in the period 1955–59 to 32,000 tons in 1961. It then increased to 47,000 tons in 1966 but it is reported to have fallen again in 1967. Consumption of synthetic rubber increased from an average 48,000 tons per annum in the period 1955–59 to 107,000 tons in 1966.

Usage by sector

Table 7 shows consumption of natural rubber by product sector in some of the major consuming countries.

In the periods 1953–55, 1961–63 and in 1964, 65 per cent of natural rubber consumed in the United States was used in the tyre industry. In 1965 and 1966 the proportion rose to 70 per cent.

Table 7
Consumption of natural rubber by product sector
('000 tons)

Country	Sector	Average 1953–55	Average 1961–63	1964	1965	1966
US	Tyres	391	297	319	361	392
	Non-tyres	214	159	171	162	166
UK	Tyres	129	79	84	89	89
	Non-tyres	112	90	100	98	95
France	Tyres	76	78	77	77	78
	Non-tyres	52	50	50	46	46
Canada	Tyres	28	24	29	31	35
	Non-tyres	14	10	12	12	12
Federal Republic of Germany	Tyres	n.a.	74	78	78	80
	Non-tyres	n.a.	72	77	75	n.a.
Japan	Tyres	n.a.	90	98	95	n.a.
	Non-tyres	n.a.	99	108	107	n.a.

n.a. : not available
Source: *Agricultural Commodities and Projections*, 1975–1985. FAO Rome, 1967

In the United Kingdom 54 per cent of natural rubber consumed was used by the tyre industry in the period 1953–55. After 1961 the proportion was steady at around 47 per cent.

In France the tyre industry absorbed a steady 61 per cent throughout the period.

In Canada the proportion of natural rubber consumed by the tyre industry increased from 67 per cent in the period 1953–55 to 71 per cent in the period 1961–63. It then increased gradually to 74 per cent in 1966.

Statistics for the whole period are not available for the German Federal Republic and Japan but from 1961 to 1965 the West German tyre industry used around 51 per cent of total natural rubber consumed while, over the same period, the Japanese tyre industry used around 48 per cent.

Table 8 shows the consumption of synthetic rubber by product sector for the same countries as in Table 7.

Table 8
Consumption of synthetic rubber
('000 tons)

Country	Sector	Average 1953–55	Average 1961–63	1964	1965	1966
US	Tyres	488	754	899	966	1041
	Non-Tyres	296	487	576	599	657
UK	Tyres	5	82	98	104	111
	Non-Tyres	7	53	71	78	82
France	Tyres	8	59	77	84	95
	Non-Tyres	8	52	64	64	73
Canada	Tyres	23	52	65	69	80
	Non-Tyres	12	22	27	28	29
Federal Republic of Germany	Tyres	n.a.	79	102	124	123
	Non-Tyres	n.a.	54	75	84	n.a.
Japan	Tyres	n.a.	49	81	88	n.a.
	Non-Tyres	n.a.	57	82	87	n.a.

n.a. : not available
Source: *Agricultural Commodities and Projections*, 1975–1985, FAO Rome, 1967

Comparison of Tables 7 and 8 gives a measure of the relative importance of natural and synthetic rubber in the tyre and non-tyre industries for the

countries concerned. In the United States natural rubber usage in the tyre industry, as a proportion of total rubber used, fell from an average 44 per cent in the period 1953–55 to around 27 per cent in the years 1961 to 1966. In the non-tyre products sector the proportion of natural rubber usage fell from an average 42 per cent in the period 1953–55 to 25 per cent in 1961–63. It then fell gradually to 20 per cent in 1966.

In the United Kingdom, the proportion of natural rubber used in terms of total rubber usage in the tyre industry fell from an average of 96 per cent in the period 1953–55 to about 45 per cent in the period 1964 to 1966. In the manufacture of non-tyre products, the proportion fell from an average of 94 per cent in the period 1953–55 to 54 per cent in 1966.

INTERNATIONAL TRADE

EXPORTS

Exports of natural rubber

Appendix 5 shows exports of natural rubber from producing countries. World exports increased from an average of 1,891,000 tons per annum in the period 1955–59 to 2,277,000 tons in 1966, an increase of 20 per cent. The main exporting countries, in decreasing order of importance, are Malaysia, Indonesia, Thailand and Ceylon.

Malaysia

Malaysia is the largest producer and exporter of natural rubber in the world. In 1966 exports from Malaysia (West Malaysia, Sabah and Sarawak) constituted 44 per cent of total world exports. Exports increased from an average 749,000 tons per annum in the period 1955–59 to 997,000 tons in 1966, an increase of 33 per cent. It is reported that exports increased by 200,000 tons in 1967.

A major importer of Malaysian rubber is Singapore which imports around 350,000 tons per annum, all of which is re-exported. Between 1964 and 1966 exports from Malaysia and Singapore averaged 1,056,000 tons per annum. In 1966 the main importers were the USSR, the US and the UK.

Table 9
Exports from Malaysia and Singapore
(Percentage by destination)

	1964	1965	1966
UK	12	11	9
US	12	12	10
Federal Republic of Germany	9	8	6
France	5	5	5
Italy	5	5	5
USSR	11	19	19
Japan	8	5	5
Others	38	35	41

Source: Derived from *Plantation Crops*, 1967

Indonesia

Over the period 1955 to 1966 Indonesian exports were fairly steady, although there was a marked decline in 1963, averaging 650,750 tons per annum as derived from estimated figures. It is reported that exports rose substantially in 1967.

The United States is the largest importer, importing 255,000 tons in 1964 (41 per cent of Indonesian rubber exports) and 291,000 tons in 1965 (43 per cent). Other large importers are China, Japan, the German Federal Republic and the USSR.

Table 10
Exports from Indonesia
(Percentage by destination)

	1963	1964	1965
US	13	41	43
China	14	17	13
Japan	1	15	13
Federal Republic of Germany	3	5	8
USSR	8	6	8
Others	61	16	15

Source: Derived from *Plantation Crops*, 1967

Thailand

Exports of natural rubber rose from an average 141,000 tons per annum in the period 1955–59 to 213,000 tons in 1964 and then fell to 199,000 tons in 1966. It is reported that exports increased substantially in 1967. Japan is the major importer followed by the United Kingdom, Malaysia and the German Federal Republic.

Table 11
Exports from Thailand
(Percentage by destination)

	1964	1965	1966
UK	18	17	16
Malaysia	12	20	16
Federal Republic of Germany	11	12	8
Japan	37	25	31
Others	22	26	29

Source: Derived from *Plantation Crops*, 1967

Ceylon

Exports averaged 94,000 tons per annum over the period 1955–63 and then rose to 133,000 tons in 1966, an increase of 41 per cent. A substantial increase is reported for 1967.

China is the major importer followed by the USSR, the US and the German Federal Republic. The proportion of Ceylonese exports going to mainland China rose from 30 per cent in 1964 to 44 per cent in 1966.

Other countries

Natural rubber is exported by many other countries including Nigeria, South Vietnam, Cambodia, Liberia and the Congo (Kinshasa).

Exports from Nigeria increased from 41,000 tons per annum over the period 1955–59 to 70,000 tons in 1966. It is reported that exports decreased in 1967 as a result of smaller production.

Exports from South Vietnam fell steadily from 82,000 tons in 1961 to 43,000 tons in 1966 and are reported to have continued falling in 1967.

Exports from Cambodia averaged 38,000 tons per annum over the period 1955–66, rising to a maximum of 68,000 tons in 1965.

Liberian exports were steady about an average 44,000 tons per annum throughout the period 1955–66, but are reported to have increased substantially in 1967.

Exports from the Congo averaged 34,500 tons per annum over the period 1955–64 but fell to 21,000 tons in 1965 and then rose to an estimated 27,000 tons in 1966.

Exports of synthetic rubber

Appendix 6 gives world exports of synthetic rubber. Total exports rose from an average of 347,000 tons per annum in the period 1955–59 to 634,000 tons in 1960. Exports then rose to 891,000 tons in 1965, an increase of 41 per cent on the 1960 total. A total of 921,000 tons were exported in 1966, not including exports from the USSR.

In 1966 the major exporting countries were the United States, Canada, the member countries of the EEC, the United Kingdom, Japan and the German Democratic Republic.

United States

The United States is by far the largest exporter of synthetic rubber. In the period 1955–59 exports averaged 186,000 tons per annum. In 1960, 345,000 tons were exported. Between 1961 and 1966 exports averaged 299,000 tons per annum. The US share of the world export market fell from 54 per cent in 1960 to 32 per cent in 1965. (Share not available for 1966 because total incomplete.) In 1966 the main importers of synthetic rubber from the United States were Canada, France, the German Federal Republic and Japan.

Table 12
Exports from the United States
(Percentage by destination)

	1964	1965	1966
Canada	8	10	12
France	9	11	12
Federal Republic of Germany	10	11	11
Japan	13	10	10
Mexico	6	6	6
Others	54	52	49

Source: Derived from *Plantation Crops*, 1967

The fall in exports to Japan reflects increasing production in Japan.

Canada

Exports of synthetic rubber from Canada increased from an average of 83,000 tons per annum in the period 1955–59 to an estimated 130,000 tons in 1966.

The main importers are the United States and the United Kingdom. Exports to the United States increased from 20 per cent of total Canadian exports of synthetic rubber in 1964 to 28 per cent in 1966. Exports to the United Kingdom were fairly steady about 15 per cent of total Canadian exports of synthetic rubber over the period 1964–66.

EEC countries

Total exports of synthetic rubber from the EEC rose from 71,000 tons in 1960 to 309,000 tons in 1966, an increase of 335 per cent. The main producer of synthetic rubber within the EEC is the Netherlands. Exports from the Netherlands increased from 7,000 tons in 1960 to 108,000 tons in 1966. The main importers were fellow members of the EEC.

France: Exports of synthetic rubber increased from 7,000 tons in 1960 to 80,000 tons in 1966.

German Federal Republic: Exports increased from 4,000 tons per annum in the period 1955–59 to 21,000 tons in 1960. They then increased to 59,000 tons in 1966.

Italy: Exports increased from 5,000 tons per annum in the period 1955–59 to 36,000 tons in 1960. They then increased to 60,000 tons in 1965 but fell to 42,000 tons in 1966. The main importers are France, the German Federal Republic and, in 1964 and 1965, the USSR.

United Kingdom

Exports of synthetic rubber averaged 1,000 tons per annum in the period 1955–59. 20,000 tons were exported in 1960. Exports rose to 58,000 tons in 1966, an increase of 190 per cent over the 1960 total. (These figures include re-exports.)

Japan

Exports increased rapidly from 1,000 tons in 1960 to 49,000 tons in 1966.

Centrally-planned countries

The main exporters of synthetic rubber within the centrally-planned countries are the German Democratic Republic and the USSR. East German exports averaged 43,000 tons per annum in the period 1955 to 1966, the main importers being the USSR and Poland.

Over the period 1955 to 1965 exports from the USSR averaged 30,000 tons per annum. Exports were somewhat higher in the second half of the period, averaging 35,000 tons per annum from 1960–65.

Imports of natural rubber

Appendix 7 shows imports of natural rubber into the principal importing countries. In 1966 the major importing countries were the United States, Japan, the United Kingdom, China, the German Federal Republic and France. Statistics of imports of natural rubber into the USSR are not available for 1966, but in the period 1960 to 1965 the USSR was second only to the United States as an importer.

United States

Over the period 1960 to 1966 US imports of natural rubber varied about a mean of 417,000 tons per annum. This was considerably less than the 564,000 tons per annum imported in the period 1955–59. In 1966, 432,000 tons were imported, a fall of 3 per cent from the 1965 level. It is reported that imports increased by 30,000 tons in 1967. Table 13 shows US imports by country of origin. The main sources are Indonesia, Malaysia and Singapore, and Liberia.

Table 13
Imports into the United States
(Percentage by country of origin)

	1964	1965	1966
Malaysia & Singapore	28	28	26
Indonesia	49	54	55
Liberia	9	10	10
Others	14	8	9

Source: Derived from *Plantation Crops*, 1967

The USSR

Imports averaged 162,000 tons per annum between 1955 and 1959 and then rose to 356,000 tons in 1962. Imports fell to 183,000 tons in 1964, rising again to 267,000 tons in 1965. Over the period 1963 to 1965, 75 per cent of imports came from Malaysia. Substantial quantities were also imported from Indonesia and Ceylon.

Japan

124,000 tons of natural rubber were imported per annum in the period 1955–59. Imports rose to 170,000 tons in 1960 and continued to rise to 226,000 tons in 1966. The main sources of Japanese imports are Indonesia, Thailand and Malaysia. Imports from Malaysia constituted 80 per cent of Japanese imports in 1959 but the proportion fell to 23 per cent in 1966. They were replaced with imports of cheaper, lower grade rubber from Indonesia and, to a lesser extent, Thailand.

Table 14
Imports into Japan
(Percentage by country of origin)

	1964	1965	1966
Malaysia	34	22	23
Thailand	38	27	26
Indonesia	17	39	42
Others	11	12	9

Source: Derived from *Plantation Crops*, 1967

United Kingdom

UK imports of natural rubber averaged 277,000 tons in the period 1955–59. 210,000 tons were imported in 1960 and 272,000 tons in 1961. Imports then fell steadily to 184,000 tons in 1966.

The United Kingdom was the second largest importer of natural rubber until 1960 but was overtaken by the USSR in 1961 and by Japan in 1964.

Table 15
Imports into the United Kingdom
(Percentage by country of origin)

	1961	1964	1966
Malaysia	47	62	35
Singapore	21		20
Nigeria	8	13	14
Indonesia	4	6	12
Thailand	7	8	7
Others	13	11	12

Source: Derived from *Plantation Crops*, 1967

The re-export trade of the United Kingdom fell with the fall in imports. Re-exports rose to 119,000 tons in 1961 and then fell rapidly to 6,000 tons in 1966.

China (mainland)

Imports of natural rubber (derived from the trade returns of exporting countries) increased from an average 107,000 tons per annum in the period 1955–59 to 113,000 tons in 1960. Imports fell to 89,000 tons in 1961 and then rose steadily to 167,000 tons in 1966.

EEC countries

Imports into all the member countries were very steady over the period 1960 to 1966. Imports into West Germany averaged 153,000 tons per annum, into France—124,000 tons per annum, into Italy—81,000 tons per annum, into the Netherlands—21,000 tons per annum and into Belgium—18,000 tons per annum.

Imports into West Germany came mainly from Malaysia and Singapore, and from Indonesia and those into France came mainly from Malaysia and Singapore and from South Vietnam.

Singapore

Singapore has a substantial import trade, almost all imports of natural rubber being re-exported. In 1963 Singapore imported 306,000 tons from Malaysia and 256,000 tons from Indonesia. Imports from Indonesia ceased after confrontation and in 1964 Singapore imported only 325,000 tons of which 318,000 tons came from Malaysia. In 1965, 367,000 tons were imported (351,000 tons from Malaysia) and in 1966, 405,000 tons (376,000 tons from Malaysia).

Imports of synthetic rubber

Appendix 8 gives imports of synthetic rubber into the principal importing countries. In 1966 these were France, Federal Republic of Germany, Italy, the United Kingdom, the USSR, Japan and Canada.

EEC countries

Total imports of synthetic rubber into the member countries of the EEC averaged 108,000 tons per annum in the period 1955–59. Imports rose to 202,000 tons in 1960 but fell to 178,000 tons in 1961. Imports then rose steadily to 300,000 tons in 1966.

In 1966 France was the main importing country. Imports averaged 47,000 tons per annum from 1955–59 and then rose to 94,000 tons in 1960. Imports fell to around 70,000 tons for three years and then rose to 97,000 tons in 1966.

Imports into West Germany increased steadily over the period from 32,000 tons per annum in the period 1955–59 to 97,000 in 1965. 90,000 tons were imported in 1966.

Imports into Italy increased from 17,000 tons per annum in the period 1955–59 to 69,000 tons in 1966.

Imports into Belgium rose from an average 7,000 tons per annum in the period 1955–59 to 26,000 tons in 1966.

Imports into the Netherlands increased from 5,000 tons per annum in the period 1955–59 to 18,000 tons in 1966.

The United States is the main single supplier of synthetic rubber to the EEC, although imports from the US are matched in size by intra-community trade. Substantial quantities are also imported from Canada and the United Kingdom.

United Kingdom

Imports of synthetic rubber fell from 57,000 tons in 1960 to 41,000 tons in 1961 after which they rose steadily to 61,000 tons in 1966. Imports came mainly from Canada, the United States and the Netherlands. Imports from the Netherlands increased rapidly from 1960 until, in 1966, the Netherlands became the major source of UK imports.

Table 16
Imports into the United Kingdom
(Percentage by country of origin)

	1960	1962	1964	1966
Canada	43	46	41	32
US	53	36	30	13
Netherlands	2	11	18	33
France	(a)	5	6	13
Others	2	2	5	9

(a) Included in Others
Source: Derived from *Plantation Crops*, 1967

The USSR

Over the period 1955–59 imports averaged 27,000 tons per annum, Over the period 1960–65 imports were fairly steady about an average of 44,000 tons. Soviet imports come mainly from Italy and the German Democratic Republic.

Japan

Over the period 1955–59 imports averaged 18,000 tons per annum. From 1960–66 imports averaged 50,000 tons per annum. The United States is the major source of Japanese imports of synthetic rubber. Substantial quantities are also imported from Canada.

Canada

Imports of synthetic rubber, which come almost entirely from the United States, rose steadily from 18,000 tons in 1960 to 41,000 tons in 1966.

STOCKS

Natural rubber

Appendix 9 gives end of year stocks of natural rubber. Except for a fall in 1963 when exports from Malaysia and Singapore increased, world stocks rose steadily from 688,000 tons in 1959 to 857,000 tons in 1966, an increase of 25 per cent. These figures include stocks in producing and consuming countries, and stocks afloat and in transit, but exclude stocks held in the USSR, mainland China, and government stockpiles.

World production of natural rubber is usually less than consumption. In 1966 production fell short of consumption by around 130,000 tons. The deficiency was more than met by US government stockpile releases. Table 17 shows stockpile deliveries from the United States and United Kingdom in the period 1959 to 1968. More and more natural rubber is being produced but hardly fast enough to meet the continuing rise in demand. In 1967, production and consumption of natural rubber was more in balance with production at 2·453 million tons against an estimated consumption of 2·465 million tons, the balance coming from releases from the US stockpile.

Table 17
Stockpile deliveries
('000 tons)

	US	UK	Total
1959	7	6	13
1960	90	63	159(1)
1961	26	4	30
1962	57	10	67
1963	85	10	95
1964	97	6	103
1965	122	—	122
1966	159	—	159
1967, Jan.–June	122		
1967/68 July–March	71		

(1) Includes 6,000 tons delivered from Italian government stockpiles
Source: *FAO Commodity Reviews* 1967, 1968

585,000 tons of natural rubber were made available from government stockpiles in the US, the UK, and Italy in disposal programmes announced in September 1959. These had been sold by mid-1965.

In August 1965 the US government announced the release of 630,000 tons of rubber for orderly disposal at prevailing market prices over 6–7 years. Deliveries were made at the rate of 30,000 tons per quarter until March 1966 when they were increased to 43,000 tons per quarter. The resulting fall in prices, to the lowest level for 18 years, induced producing countries, particularly Malaysia, to appeal for a reduction. The US government agreed to limit sales to 30,000 tons per quarter from 1/1/67. This had little material effect on the market, particularly as Malaysian output continued to rise. The US then agreed to limit deliveries to 70,000 tons per annum from 1/7/67. In the meantime, the Malaysian government bought rubber in the market thus supporting the price. An estimate of the amount bought has been put at 100,000 tons, costing some £16 million. This economically brave policy ameliorated the situation for a period. The background and aftermath of this policy is dealt with in greater detail in the following section on 'Prices'. In August 1968 it was announced that releases from the US stockpile would continue at the rate of 70,000 tons per annum but that the policy of dividing this total up into quarterly allotments of 17,500 tons would be abolished. Buyers were then able to purchase any quantity at any time up to the maximum of 70,000 tons.

It had been declared that the US government stockpile would be run down to a level of 132,000 tons, a total which would have been reached by 1972 at the present rate of disposal. However, in February 1969, the US General Services Administration decided to stop rubber sales from the stockpiles. This resulted in an immediate boost to prices and RSS No. 1 on the London market reached its highest level for six years.

Synthetic rubber

Appendix 10 gives end of year stocks of synthetic rubber. World stocks, excluding government stocks, increased from 335,000 tons in 1959 to 677,000 tons in 1966, an increase of 102 per cent. In 1966 the major stockholders, in decreasing order of importance were the United States (348,000 tons), France (55,000 tons), Japan (46,000 tons), Canada (28,000 tons) and the United Kingdom (25,000 tons).

United Kingdom stocks of synthetic rubber fell from 29,000 tons in 1965 to 25,000 tons in 1966 but stocks held in all the other major stockholding countries increased over the same period.

PRICES

Appendix 11 gives selected wholesale, export and import prices of natural rubber and US wholesale prices of synthetic rubber. Annual figures, that is averages of daily prices throughout each year, are available up to 1966. Also shown are monthly average prices for all categories from April 1966 to August 1967 and for exports from Singapore to May 1968.

Rubber from Malaysia and Singapore is a market leader to the extent that world rubber prices tend to reflect prices current in Singapore and London markets.

The price of exports of RSS1 from Singapore fell from an annual average price of 108·1 cents/lb f.o.b. in 1960 to 65·4 cents/lb in 1966. Over the same period the price of exports of RSS3 fell from 104·9 cents/lb to 63·8 cents/lb.

In London the price of RSS3 fell from 30·6 pence/lb c.i.f. in 1960 to 19·1 pence/lb in 1966.

The monthly average price of exports of RSS1 from Singapore fell from 68·7 cents/lb f.o.b. in May 1966 to 45·4 cents/lb in February 1968. Over the same period the price of RSS3 fell from 66·2 cents/lb to 43·5 cents/lb. Prices began to rise in March 1968 and have continued to do so. RSS1 was quoted at 57·25 cents/lb in August 1968. Figure 1 shows these price movements. There tends to be a seasonal recovery of prices in September and October each year when the main part of the new crop reaches the market and consumers start their Autumn buying season. This recovery can be seen clearly in 1966 and is observable in 1967. The rise in prices occurring in June 1967 was a result of the Middle East crisis while that in late 1967 was a result of the support buying policies of the Malaysian government. Prices tended to fall faster in the second half of 1967 than in the first as consumption of natural rubber declined because of strikes and economic recessions in consuming countries.

A consideration of the price trends of natural rubber over the last few years shows the major factors which have affected, and in many cases continue to affect, the price of rubber.

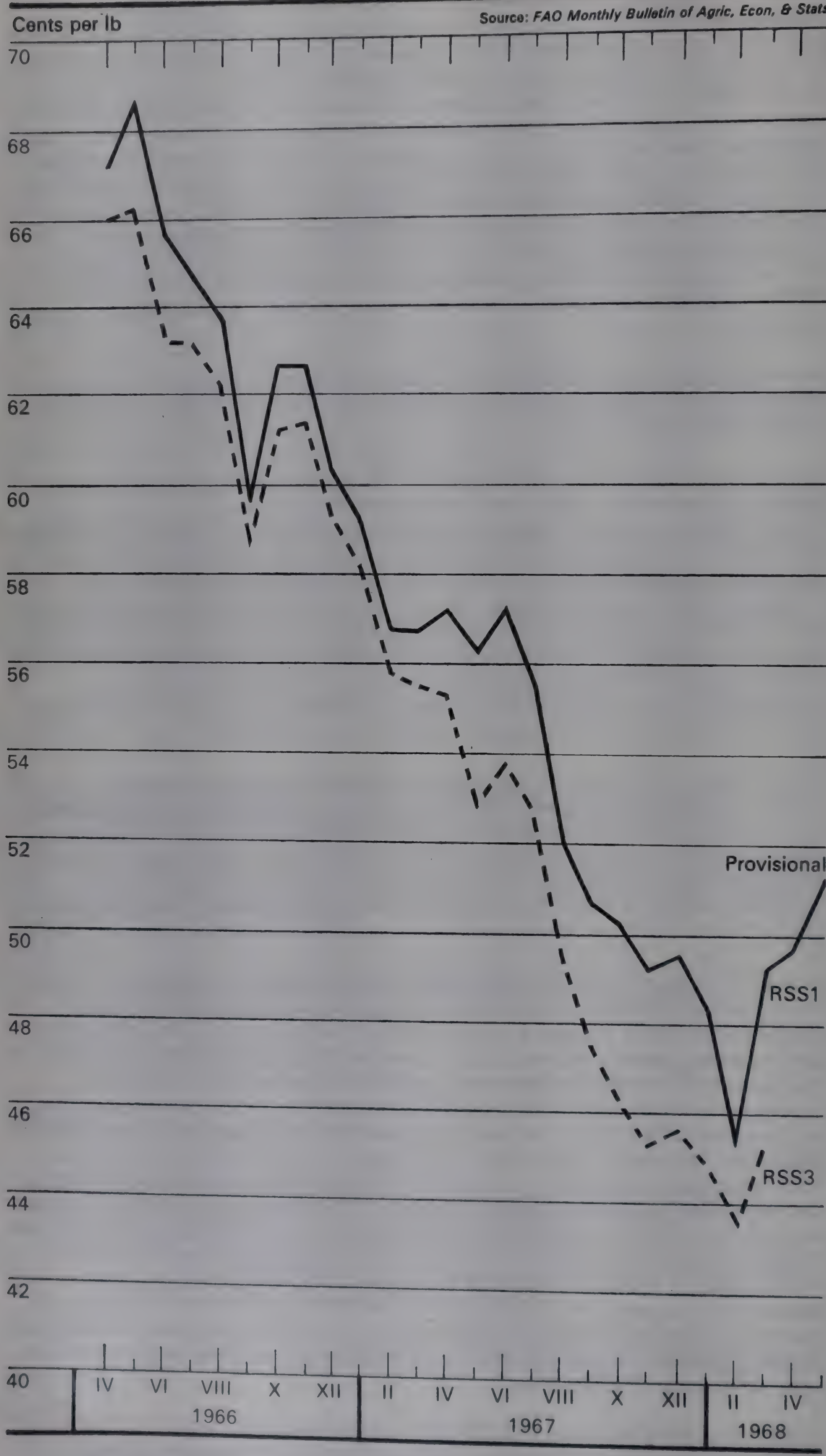
The general fall in prices commenced in 1960 and continued, except for a slight improvement in 1965, until early 1968. Prices were firm during the first half of 1965 because the market expected imports into the USSR and because there were no supplies from Indonesia as a result of confrontation. Prices on the London market were firm because of a shortage of nearby rubber in London. Prices began to fall again in July 1965 following announcements of coming stockpile releases by the US government and reductions in the price of synthetic rubber. Also natural rubber production had increased after the wintering period. Prices recovered at the end of 1965 after substantial purchases by the USSR and East European countries and as a result of rising demand in the United States, particularly in the car industry.

Prices began to fall again in mid-1966 following the announcement of further US stockpile releases. The decline was accelerated by several factors: (a) a sudden influx of Indonesian supplies was expected via the Singapore market and (b) purchases by the USSR and mainland China levelled off and there were signs of deflationary tendencies in several western European countries. After the end of confrontation, Indonesia re-entered the Singapore market in late 1966 and these additions to supply perpetuated the price decline.

In 1967 the rate of US stockpile release was cut but prices continued to fall. This reflected the lessened activities of the motor industries of the United States and Western Europe, a 10 per cent cut in the price of synthetic rubber, and increasing stocks in producing countries. Prices continued to fall until mid-September when the Malaysian government announced a support buying scheme whereby they would buy rubber from producers and sell direct to consumers. This policy had some success and prices began to recover. In December, however, prices began to fall again and continued to do so into 1968 reaching, in February, the lowest level since 1949. Continued buying by the Malaysian government failed to halt this fall which was caused by several factors: (a) Chinese dealers were releasing stocks in order to pay staff bonuses for the Chinese New Year, (b) 12,000 tons of rubber were dumped on the market when it was rumoured that the Suez Canal would re-open, (c) production increased by 18,000 tons in December and (d) the £ sterling was devalued in November 1967 and there was an economic squeeze in the United States. However, the support policy of the Malaysian government cannot but have ameliorated the situation.

In February 1968 the price of RSS1 fell to 44⅝ Malaysian cents/lb f.o.b. Singapore, the lowest price since 1949 and then prices began to recover reaching 57¼ cents/lb by August 1968. The rise in price was caused by

Figure 1
Natural rubber Prices of exports from Singapore



simultaneous increases in demand and falls in supply. The USSR and mainland China increased their purchases while delays in the arrival of Indonesian rubber led to an unusually large amount of covering in west European countries. Supplies were lowered by particularly severe and early wintering of trees in Malaysia. It has been stated that demand increased to such an extent that all the stocks held in Malaysia as a result of the government purchasing scheme were absorbed and that, finally, a profit was made on the resale.

To summarize, the main groups of factors causing the severe decline in the price of natural rubber in recent years were as follows:

a. Overproduction in Malaysia as estates were replanted with high-yielding clones plus the addition to supplies following the re-entry of Indonesian rubber on to world markets.
b. Heavy releases from United States government stockpiles.
c. The tendency of the centrally-planned countries, particularly the USSR and mainland China, to buy rather spasmodically.
d. The lower levels of economic activity in most developed countries.
e. Competition from synthetic rubber.

Synthetic rubber is currently in plentiful supply as a result of the world oil glut and, for the uses in which it is competitive, provides a low long-term price ceiling for natural rubber. Natural rubber can remain competitive only by lowering production costs and there is some evidence that efficient producers are able to get costs down to an average of 9d or 10d a pound as the result of replanting with higher yielding trees. Yields an acre are rising rapidly with the national average in Malaysia of 950 lb—more than double that of 1951. Yields of 1,200 to 1,500 lb of rubber per acre a year are regularly returned and some experimental stands have yielded 3,500 lb an acre. It is not yet known to what extent reductions in costs resulting from increased productivity will be offset by rising wages and other direct costs.

In the long run the price ceiling will most probably be the price of *cis*-polyisoprene since this synthetic rubber appears to present the greatest long-term threat to natural rubber. No decreases in the price of this synthetic rubber are expected in the immediate future(1) but are very likely to occur in the long-term as a result of technological development and the economies of scale derived from increased production. In Malaysia it is believed that while orderly marketing of both natural and synthetic rubbers might prevent price declines such as that of recent years, in the long run the price trend of natural rubber will not be favourable to producers.(2)

The size of the US stockpile is still considered in many quarters to be a threat to the market and the US/GSA decision, early in 1969, to stop sales from the stockpile is regarded merely as a temporary palliative, albeit a welcome one.

FUTURE PROSPECTS

It has been forecast(3) that world supplies of natural and synthetic rubber could increase by between 8 and 9 per cent in 1968.

It is believed that natural rubber production could increase by around 3 per cent. The increase in supplies of natural rubber are expected despite reductions in US stockpile releases and the fact that Indonesian production will most

---

(1) *FAO Commodity Review*, 1967

(2) Deputy Prime Minister, Tun Abdul Razak—reported in *The Public Ledger* 24.2.68

(3) *FAO Commodity Review*, 1968

probably be less than the very high levels reported in 1967. There seems every likelihood that world production will continue to increase into the 1970's. Replanting with high-yielding material continues apace in many countries and substantial increases in world supplies of natural rubber are to be expected when these trees attain productive age. High yield trees take about 12 years to reach maturity. A significant proportion of the newly planted material has not yet reached maturity and it has been calculated that in Malaysia, for instance, even without further planting production could increase by up to 400,000 tons per annum by 1970.

Replanting in Ceylon is encouraged by a Rubber Replacement Subsidy but the rate of replanting has fallen in recent years. None the less production is expected to increase by a further 50,000 tons per annum when the high-yielding replants mature. Similar development plans and subsidies are in operation in Ghana, India, Liberia, Nigeria and Thailand.

The supply of synthetic rubber could increase by up to 10 per cent in 1968[(1)] if the centrally-planned countries, particularly the USSR, continue their recent rates of expansion. New plants coming on stream in the United States should increase US production by more than 200,000 tons. Substantial production increases are also expected in Japan and France.

Other countries planning to start production of synthetic rubber by 1970 include Algeria, Egypt, Israel and Venezuela.

It is expected that total demand for elastomers will increase more rapidly in 1968 than in 1967 but that the demand for synthetic rubber will continue to increase at a greater rate than that for natural rubber. Thus, although the demand for natural rubber is expected to increase, its share of the total elastomer market will continue to fall.

It is expected that the demand for tyres and tyre products and hence the demand for rubber will expand in the United States, Japan, Italy and the German Federal Republic. Tyre usage could increase in the United Kingdom following the Tyre Regulations issued on 1st April 1968 which will most probably lead to more frequent discarding of old tyres. The USSR plans to increase production of passenger cars by 10 per cent per annum until 1970. It is expected, however, that the increase in Soviet demand for elastomers will be met to an increasing extent with synthetic rubber.

It is also expected that the quantity of natural rubber used in automobile tyres will increase with the increasing adoption of radial-ply tyres, which use more natural rubber per tyre than the older type of tyres, and as a result of the development of the cheaper oil-extended natural rubber.

The International Rubber Study Group, meeting in Lagos in 1966, forecast that by 1970 the production of natural rubber would exceed consumption by 15,000 tons and that in 1971 production could exceed consumption by 170,000 tons. It seems likely, therefore, that stocks will accumulate in producing countries.

Accumulating stocks of natural rubber and increasing production of synthetic rubber mean that the price of natural rubber is unlikely to increase significantly in the future. However, the demand for natural rubber is expected to increase, albeit less than the demand for synthetic rubber. It is therefore of prime importance that costs of production be reduced, mainly by increased productivity, and that natural rubber should be presented in a form which increases its competitiveness with synthetic rubber. This need for competitiveness appears to have been recognized, at least by Malaysia, and steps are being taken to bring it about.

---

(1) *FAO Commodity Review*, 1968

BIBLIOGRAPHY

Plantation Crops, Commonwealth Secretariat, London, 1967. No. 11.

Financial Times 29.7.68.

FAO Commodity Review 1967, FAO, Rome, 1967.

FAO Commodity Review 1968, FAO, Rome, 1968.

Agricultural Commodities and Projections 1975–1985, FAO Rome, 1967.

Rubber by L. G. Polhamus, Leonard Hill (Books) Ltd., London, 1962.

Rubber: Natural and Synthetic by H. J. Stern, Maclaren and Sons Ltd., London, 1954.

The Natural Rubber Producers' Research Association, Thirtieth Annual Report, June 1968.

Progress of Rubber Technology, The Institution of the Rubber Industry, 1967, **31**.

Public Ledger, 24.2.68. Reported speech by Deputy Prime Minister of Malaysia, Tun Abdul Razak.

Appendix

INTERNATIONAL DESCRIPTIONS OF THE GRADES OF RIBBED SMOKED SHEET RUBBER

Wet, bleached, under-cured and virgin rubber and rubber that is not completely visually dry at the time of buyers' inspection is not acceptable. (Except slightly under-cured rubber as specified for No. 5 and No. 6 RSS.)

Skim rubber made of skim latex shall not be used in whole or in part in the production of any grade.

Nothing but coagulated rubber sheets, properly dried and smoked, can be used in making these grades; block, cuttings or other scrap or frothy sheets, weak, heated or burnt sheets, air dried or smooth sheets not permissible.

No. IX RSS

The grade must be produced under conditions where all processes are carefully and uniformly controlled.

Each bale must be packed free of mould but very slight traces of dry mould on wrappers or bale surfaces adjacent to wrapper found at time of delivery will not be objected to provided there is no penetration of mould inside the bale.

Oxidized spots or streaks, weak, heated, under-cured, over-smoked, opaque and burnt sheets are not permissible.

The rubber must be dry, clean, strong, sound and evenly smoked, and free from blemishes, specks, resinous matter (rust), blisters, sand, dirty packing and any other foreign matter. Small pinhead bubbles, if scattered, will not be objected to.

No Official International Sample has been established for this grade.

No. 1 RSS

Each bale must be packed free of mould but very slight traces of dry mould on wrappers or bale surfaces adjacent to wrapper found at time of delivery will not be objected to provided there is no penetration of mould inside the bale.

Oxidized spots or streaks, weak, heated, under-cured, over-smoked, opaque and burnt sheets are not permissible.

The rubber must be dry, clean, strong, sound and free from blemishes, resinous matter (rust), blisters, sand, dirty packing and any other foreign

matter, except slight specks as shown in sample. Small pinhead bubbles, if scattered, will not be objected to.

No. 2 RSS

Slight resinous matter (rust) and slight amounts of dry mould on wrappers, bale surfaces and interior sheets, found at time of delivery will not be objected to, provided these conditions, either singly or in combination, do not exist to an objectionable extent on and in more than 5% of the number of bales included in the delivery, lot or tender as determined by the number of bales inspected.

Small bubbles and slight specks of bark, if scattered, will not be objected to.

Oxidized spots or streaks, weak, heated, under-cured, over-smoked, opaque and burnt sheets are not permissible.

The rubber must be dry, clean, strong, sound and free from blemishes, blisters, sand, dirty packing and all other foreign matter other than specified above as permissible.

No. 3 RSS

Resinous matter (rust) and dry mould on wrappers, bale surfaces and interior sheets, found at time of delivery will not be objected to, provided these conditions, either singly or in combination, do not exist to an objectionable extent on and in more than 10% of the number of bales included in the delivery, lot or tender as determined by the number of bales inspected.

Slight blemishes in colour, small bubbles and small specks of bark permissible.

Oxidized spots or streaks, weak, heated, under-cured, over-smoked, opaque and burnt sheets are not permissible.

The rubber must be dry, strong and free of blemishes, blisters, sand, dirty packing and all other foreign matter other than specified above as permissible.

No. 4 RSS

Resinous matter (rust), dry mould on wrappers, bale surfaces and interior sheets, found at time of delivery will not be objected to provided these conditions, either singly or in combination, do not exist to an objectionable extent on or in more than 20% of the number of bales included in the delivery, lot or tender as determined by the number of bales inspected.

Medium size bark particles, bubbles, translucent stains, slightly sticky and slightly over-smoked rubber are permissible to the extent shown in the sample.

Oxidized spots or streaks, weak, heated, under-cured, over-smoked (in excess of the degree shown in the sample), opaque and burnt sheets are not permissible.

The rubber must be dry, firm and free of blemishes, blisters, sand, dirty packing and all other foreign matter other than specified above as permissible.

No. 5 RSS

Resinous matter (rust), dry mould on wrappers, bale surfaces and interior sheets, found at time of delivery will not be objected to provided these

conditions, either singly or in combination, do not exist to an objectionable extent on or in more than 30% of the number of bales included in the delivery, lot or tender as determined by the number of bales inspected.

Large bark particles, bubbles and small blisters, stains, over-smoked, slightly sticky rubber, and blemishes are permissible of the amount and size shown in the sample. Slightly under-cured rubber permissible.

Weak, heated, burnt, oxidized spots or streaks NOT permissible.

The rubber must be dry, firm, free of blisters, except to the extent shown in the sample, dirty packing, sand, and all other foreign matter other than specified above as permissible.

No. 6 RSS

Resinous matter (rust), dry mould on wrappers, bale surfaces and interior sheets, found at time of delivery will not be objected to provided these conditions, either singly or in combination, do not exist to an objectionable extent on or in more than 35% of the number of bales included in the delivery, lot or tender as determined by the number of bales inspected.

Extra large bark particles, bubbles and blisters, stains, over-smoked, slightly sticky rubber, blemishes, slightly oxidized spots or streaks are permissible of the amount and size shown in the sample. Slightly under-cured rubber permissible.

Weak, heated, or burnt sheets not permissible.

The rubber must be dry, firm, free of dirty packing, sand and all other foreign matter other than specified above as permissible.

GLOSSARY OF TERMS

1 *Bark specks or particles*

Literally it is the external covering of the woody stems, branches and roots of plants but in rubber it includes all foreign matter of organic origin.

2 *Blemishes*

Any defects, stains or disfigurements not elsewhere classified except for slight milling disfigurements on Ribbed Smoked Sheets.

3 *Blister*

A sac, pit, pocket or depression on or in a sheet of rubber resulting from decomposition and gas formation during the processing operations. The inner surfaces of blisters are frequently sticky.

4 *Bubbles*

Small round globules of air or gas within the rubber formed during the coagulation process by trapped air or slight fermentation. The surfaces inside a bubble are usually dry and are not sticky.

5 *Bleached rubber*

See Virgin Rubber.

6 *Burnt sheets*

Rubber which has been charred as a result of too close contact to smoke fires, resulting in black oxidized condition.

7 *Clean*

This term when used in grade descriptions refers to a determination made by visual inspection and comparison to the pertinent sample.

8 *Dirty packing*

Any foreign matter such as grass, reeds, rattan slivers, paper, pieces of cloth, wood splinters or any other foreign matter not listed under the specifications as permissible.

9 *Dry rubber*

The complete absence of any evidence of moisture as determined by visual inspection. (See also Bleached, Under-cured and Virgin Rubber.)

10 *Firm rubber*

Rubber which is uniformly strong and solid as contrasted to rubber which is weak and spongy.

11 *Foreign matter*

Any material whatsoever other than rubber hydrocarbon and the natural substances inherent in rubber latex.

12 *Frothy sheets*

Sheets containing excess bubbles or blisters to the extent that the entire sheet shows nothing but this condition, caused by excess fermentation during the coagulation process. These sheets are soft and deteriorated as a result of poor preparation.

13 *Heated rubber*

Soft sticky spots or streaks appearing in the rubber, regardless of cause.

14 *Opaque sheets*

A black, opaque condition on the surface sheets (principally 4, 5 and 6 RSS) with evidence of oxidation.

15 *Over-smoked rubber*

Rubber which has been smoked so heavily as to have become almost opaque. This description does not include rubber which has been slightly charred as a result of too close contact to smoke fires.

16 *Oxidized rubber*

Rubber hydrocarbon, any of its serum constituents, or any foreign matter within the rubber which has combined with oxygen to deteriorate or degrade the rubber.

17 *Resinous matter* (*rust*)

Non-rubber, brownish deposit or film occurring on the surface of smoked sheets and is sometimes not apparent until the sheet is stretched or scratched.

18 *Sand*

The more or less fine debris of rocks, consisting of small, loose grains, often of quartz.

19 *Skim latex*

The residual liquid, of very low dry weight rubber content, being the by-product of the concentration of normal liquid latex.

20 *Sound rubber*

Free from any defect or weakness.

21 *Sticky rubber*

Tacky, viscous or gluey rubber.

22 *Strong rubber*

Property of resisting strain or tension.

23 *Under-cured rubber*

Portions of rubber which have not been thoroughly dried during the smoking or drying processes.

24 *Weak rubber*

(Sometimes known as 'short' rubber.) Ribbed Smoked Sheet which tears easily or breaks on application of sudden tension.

25 *Virgin rubber*

Rubber which still retains enough of the original moisture present as to present a whitish appearance as contrasted to 'bleached rubber' which is rubber which has become wet and has absorbed excess moisture.

Source: *International Standards of Quality and Packing for Natural Rubber Grades (The Green Book)* Effective from 1st July 1962, Published by The Rubber Manufacturers Association, Inc. (USA).

STANDARD MALAYSIAN RUBBER

Specifications

1 Standard Malaysian Rubber (SMR) is natural rubber supplied from the States of Malaya and such other parts of Malaysia as may be approved.

2 SMR is packed in compressed block form in bales not exceeding 112 lb preferably in 70 lb bales of dimensions 28" x 14". It is wrapped in polyethylene sheet or other approved material. It is free of any other bale coating.

3 SMR is graded by technical specifications, not by the conventional visual standards given in the 'Green Book' of the Rubber Quality and Packing Conference.

4 The maximum limits for the non-rubber constituents of the three SMR grades are:

		SMR-5	SMR-20	SMR-50
Dirt	(%)	0·05	0·20	0·50
Ash	(%)	0·5	1·0	1·5
Copper	(ppm)	8	8	8
Manganese	(ppm)	10	10	20
Nitrogen	(%)	0·7	0·7	0·7
Volatile Matter	(%)	1·0	1·0	1·0

5 Three levels of PRI denoted by H, M and S are marked on the bales inside the registered symbol and have the following significance.

H—PRI not less than 80
M—PRI not less than 60
S—PRI not less than 40

(At present this is not a guarantee mark and while every effort will be made to see that the large majority of bales will satisfy the requirements, no claims can be made on the basis of PRI.)

6 While colour forms no part of this technical specification, light coloured rubbers satisfying the RRIM colour standards and falling within the SMR 5 grade only may be specifically designated as SMR 5L. Rubbers prepared directly from latex by some of the new processes and by processes similar or equivalent to that now used for producing pale ADS will normally meet this colour standard; other rubbers will normally not do so.

7 Suppliers of SMR of any quality are required to register with the Malayan Rubber Export Registration Board and with the RRIM. For registration and use of the symbol

(i) typical samples of proposed SMR must be submitted;
(ii) the SMR specification which these intend to meet must be stated: (SMR 5L, SMR 5, SMR 20 or SMR 50);
(iii) the RRIM will then determine and specify the quality standard to which the samples conform and, when so requested, whether the 5L standard is satisfied;

(iv) arrangements for quality testing and control must be approved by the RRIM;

(v) baling and packing procedures must be stated.

8 Bales of SMR must be marked with the registration SMR symbol, the authorised grade, and the producer's code letters: the preparation type (*e.g.* pale crepe, sheet, compacted granules, brown crepe) and weight must also be shown. Advice notices must be similarly explicit.

9 SMR will be assessed only on the standards stated above and not by conventional International Type Grading. Complaints and disciplinary action will be considered by the Malayan Rubber Export Registration Board, with technical advice from the RRIM, on this basis alone.

10 The RRIM in consultation with Malayan Rubber Export Registration Board, reserves the right to amend these specifications after due notice has been given.

Source: *Standard Malaysian Rubber, 3,* Rubber Research Institute of Malaya, Chemical Division, April 1966.

Notes

Copper and manganese content are included in the specifications as a measure of the ageing properties of the rubber, that is the resistance to oxidative breakdown. The Plasticity Retention Index (PRI) has been developed as a more positive means of assessing ageing. PRI is at present only associated with the SMR scheme but it is intended that it will eventually replace the trace metal measurements and be acceptable as a single sufficient criterion of resistance to oxidative breakdown.

The PRI is the percentage of the viscosity of a sample of raw rubber which is retained after artificial ageing. The ageing is carried out by heating the sample for 30 minutes at 140°C. The viscosity measurements are made in a Wallace Rapid Plastimeter.

$$\text{PRI} = \frac{\text{Viscosity after ageing}}{\text{Viscosity before ageing}} \times 100.$$

Statistical Appendix

Table A1
Natural Rubber
Production in principal producing countries

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Total	'000 tons	1,958	1,990	2,095	2,130	2,068	2,238	2,343	2,400
of which in:									
Malaysia (a)		715	780	808	817	855	893	936	988
Ceylon		96	97	96	102	103	110	116	129
India		23	25	27	31	37	44	49	52
Brunei		1	2	2	2	1	1	1(c)	1(c)
Papua		4	4	4	4	5	5	5	6(c)
Nigeria		40	59	55	59	63	71	68	76(c)
Indonesia		697	610	671	671	573	638	706	700(c)
Thailand		142	168	183	192	187	218	213	204
Vietnam		70	75	78	74	71	73	60	48
Cambodia		31	37	39	41	40	45	48	51
Cameroun		4	4	5	4	4	5	6(c)	6(c)
Burma (b)		12	9	10	11	9	9	9	9(c)
Congo (Kinshasa)		35	35	37	37	37	34	21	27(c)
Liberia (b)		40	48	41	45	41	42	48	52(c)
Brazil		22	23	22	21	20	28	29	24
Other Countries		26	14	17	19	22	22	28	27

(a) West Malaysia, Singapore, Sabah, Sarawak
(b) Exports
(c) Estimates
Source: Derived from *Plantation Crops*, Commonwealth Secretariat, No. 11, 1967

Table A2
Synthetic Rubber
Production in principal producing countries

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Total	'000 tons	1,367	1,984	2,094	2,361	2,567	2,952	3,173	3,500
of which in:									
United Kingdom		14	90	106	117	125	153	172	191
Canada		119	160	164	168	179	197	203	200
Australia		—	—	3	14	17	18	21	20
India		—	—	—	—	7	12	15	15
United States		1,121	1,436	1,404	1,574	1,608	1,765	1,813	1,970
France		1	17	40	63	97	128	146	161
Italy		13	66	82	86	95	110	118	120(a)
Netherlands		—	12	40	45	85	90	100	110
German Federal Republic		21	80	86	88	106	136	161	182
Belgium		—	—	—	—	—	15	20	20(a)
German Democratic Republic		77	85	88	89	88	92	93	100
Poland		1	20	31	33	35	39	39	37
Rumania		—	—	—	—	6	19	30	35
Czechoslovakia		—	—	—	—	—	20	30	30(a)
South Africa		—	—	—	—	—	6	15	18
Japan		—	18	50	68	90	120	159	228
Brazil		—	—	—	16	29	32	35	53
Argentina		—	—	—	—	—	—	3	10

(a) Estimated
Source: Derived from *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A3
Natural Rubber
Consumption

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
In:									
United Kingdom	'000 tons	201	181	168	164	169	181	184	181
Canada		42	35	32	35	36	40	43	47
Australia		39	37	29	33	36	38	36	34
India		32	45	48	51	59	59	64	66
United States		555	479	427	463	457	482	515	550
German Federal Republic		138	146	136	146	150	153	155	155
France		135	127	127	125	125	125	121	122
Italy		56	74	79	79	87	81	86(a)	90(a)
Sweden (b)		20	22	20	22	23	23	25	22
Belgium (b)		17	15	15	14	16	17	17	18
Netherlands		20	21	21	20	20	22	21	20
South Africa (b)		23	19	17	18	21	30	29	21
Brazil		40	44	39	40	36	32	26	30
Argentina (b)		28	22	33	22	19	29	28	23(a)
Japan		123	166	176	190	192	203	198	213
China (a)		77	120	83	107	108	142	135	167
Czechoslovakia (b)		40	62	64	27	52	45	45	34(a)
Rumania (b)		6(c)	9	11	14	19	22	19	24
Poland (b)		27	32	35	36	32	39	35	41
German Democratic Republic (b)		13	23	24	23	24	30	28	29
USSR (b)		140	170	330	330	270	160	240	276(a)

(a) Estimated
(b) Net imports
(c) Average, 1958–59 only
Source: *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A4
Synthetic Rubber
Consumption

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
In:									
UK	'000 tons	53	116	121	133	144	166	180	190
Canada		48	56	63	73	84	91	96	107
Australia		12	25	23	25	33	35	37	36
India		3	6	9	10	11	14	20	22
US		930	1,079	1,102	1,256	1,307	1,452	1,541	1,672
German Federal Republic		47	104	120	129	143	174	205	209
France		44	91	96	108	123	139	145	165
Netherlands		5	12	13	14	15	18	20	23
Italy		22	57	64	72	91(a)	95(a)	111(a)	127(a)
Belgium(b)		7	12	14	16	19	22	25	26
South Africa(c)		11	15	15	17	18	26	22	22
Sweden(b)		7	16	16	20	21	26	32	34
Japan		15	61	84	104	126	160	173	219
Brazil		3	16	20	29	34	40	37	51
Argentina(b)		5	12	18	17	15	29	37	38(a)
Czechoslovakia(a/c)		14	20	23	22	22	40	45	47(a)
Rumania(c)		7(d)	9	12	12	21	18	24	29
Poland(c)		13	25	30	39	43	50	52	59
German Democratic Republic(c)		35	37	46	44	47	50	52	61
USSR(a)		260	350	260	310	430	600	580	610
China(a)		1	16	14	—	—	—	1	6

(a) Estimated
(b) Net Imports
(c) Production + Net Imports
(d) Average, 1958–59 only
Source: *Plantation Crops*. Commonwealth Secretariat, 1967, No. 11

Table A5
Natural Rubber
Exports

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Total	'000 tons	1,891	1,958(b)	2,077	2,075	2,016	2,126	2,250	2,277
of which from:									
Malaysia(d)		749	839	861	856	908	914	951	997(e)
Brunei		1	2	2	2	2	2	1	1
Papua		4	4	4	5	5	5	6	6
Ceylon		92	105	88	100	94	113	119	133
Nigeria(c)		41	57	55	60	63	72	67	70
Indonesia(a)		679	577	667	650	552	617	684	677
Thailand		141	167	182	191	184	213	208	199
South Vietnam		67	69	82	73	68	70	56	43
Cambodia		30	40	39	36	42	24	68	50
Burma		12	10	10	11	11	9	8	7(a)
Liberia		41	48	41	45	41	42	48	52
Congo (Kinshasa)		33	35	37	37	37	34	21	27(a)
Cameroun(c)		3	4	9	8	9	9	10	10
Ivory Coast		—	—	—	—	—	2	3	5

(a) Estimates—RSG; figures for Indonesia include non-reported shipments
(b) Including Ghana, 1
(c) Shipments from W. Cameroun included with Nigeria until September, 1960; then with Cameroun
(d) Includes W. Malaysia, Sabah and Sarawak
(e) Of which Sarawak—34,000 tons and Sabah—24,000 tons
Source: Derived from *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A6
Synthetic Rubber
Exports

		Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Total	'000 tons	347	634	625	667	722	857	891	921(b)
of which from:									
UK		1	20	21	28	35	42	51	58
Canada		83	108	117	113	118	136	129	130(a)
US		186	345	297	304	283	321	282	309
Belgium		—	—	—	—	—	15(a)	20(a)	20(a)
France		—	7	10	24	41	57	73	80
Netherlands		—	7	22	40	61	78	92	108
Italy		5	36	45	41	52	54	60	42
German Federal Republic		4	21	18	24	39	44	53	59
German Democratic Republic		43	49	43	45	41	42	41	39
Poland		—	9	10	10	7	5	4	2
Rumania		—	—	—	—	1	6	11	13
Brazil		—	—	—	—	1	5	7	10
South Africa		—	—	—	—	—	—	1	2
Japan		—	1	5	6	8	16	30	49
USSR		25(a)	31	37	32	35	36	37	n.a.

n.a. : Not available
(a) Partially estimated
(b)Total incomplete
Source: Derived from *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A7
Natural Rubber
Imports

	Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Into:								
UK '000 tons	277	210	272	231	199	198	196	184
Canada	44	35	32	37	38	43	45	50
Australia	38	37	28	34	37	39	38	31
India	9	21	24	26	26	20	16	15
German Federal Republic	140	152	135	141	150	164	168	161
France	135	130	124	121	125	125	119	127
Italy	57	68	78	79	87	88	82	85
Netherlands	19	21	22	21	21	21	22	23
Belgium	20	18	18	16	18	19	18	19
Sweden	20	23	21	24	24	25	29	27
Austria(a)	11	11	11	11	11	12	13	12
Spain	21	22	23	24	33	34	36	41
Yugoslavia	8	13	15	15	16	18	18	17
Poland	27	32	35	36	33	39	35	41
Czechoslovakia	40	62	64	27	52	45	45	n.a.
Hungary	8	10	12	13	14	15	15	17
German Democratic Republic	13	23	24	23	24	30	28	29
Rumania	6(d)	9	11	14	19	22	19	25
USSR	162	188	355	356	294	183	267	n.a.
US	564	411	391	422	380	441	435	432
Mexico	15(b, d)	15	13	13	14	16	18	18
Brazil	15	14	13	10	20	8	3	6
Argentina	28	22	33	22	19	29	28	22
South Africa	23	19	17	18	21	30	27	21
Japan	124	170	183	190	185	212	207	226
China(c)	107	113	89	93	117	138	146	167

n.a. : not available
(a) Includes some gutta-percha and balata
(b) Includes synthetic latex, Canada 1955–56 only
(c) From returns of exporting countries
(d) Average 1958–59 only
Source: *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A8
Synthetic Rubber
Imports

	Average 1955–59	1960	1961	1962	1963	1964	1965	1966
Into:								
UK '000 tons	44	57	41	51	53	58	54	61
Canada	15	18	19	26	24	27	30	41
Australia	13	27	14	16	15	16	17	16
India	3	9	9	11	9	4	4	4
France	47	94	70	67	73	76	78	97
German Federal Republic	32	49	51	63	77	84	97	90
Italy	17	34	33	35	41	46	53	69
Belgium	7	13	14	16	20	22	24	26
Netherlands	5	12	10	10	10	14	16	18
Sweden	8	15	17	20	21	27	31	35
Spain	2	9	13	17	22	28	34	49
Austria	4	8	8	12	12	14	15	18
Czechoslovakia	14	20	23(a)	22(a)	22(a)	20(a)	15(a)	n.a.
Rumania	7(b)	9	12	12	17	5	5	7
Poland	12	14	9	16	15	16	17	24
USSR	27	36	55	37	39	44	53	n.a.
US	9	9	12	14	19	32	40	45
Mexico	14(b)	18	22	24	25	32	30	35
Brazil	3	17	23	17	10	12	10	11
Argentina	4	12	19	17	15	29	37	9
Venezuela	n.a.	7	8	11	10	15	13	14
Japan	18	50	44	49	54	56	49	46
South Africa	11	15	15	17	18	20	8	6

n.a. : not available
(a) Exports from USSR, Poland and German Democratic Republic
(b) Average 1958–59 only
Source: *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A9
Natural Rubber
End of Year Stocks

		1959	1960	1961	1962	1963	1964	1965	1966
Total (a, b)	'000 tons	688	745	748	758	703	808	812	857
of which in:									
West Malaysia		64	75	76	103	87	90	88	100
Singapore		44	59	47	53	25	44	26	46
Indonesia(c)		75	75	75	75	75	75	75	75
Ceylon		24	16	23	24	32	26	19	23
Vietnam		8	12	9	9	10	10	9	8
Cambodia		5	6	6	6	5	6	7	6
UK(b)		20	33	23	25	24	23	25	26
US(b)		79	77	68	70	61	87	100	82
Canada		4	4	4	4	3	4	4	5
Brazil		3	3	2	2	4	7	10	7
Australia		3	3	2	4	5	6	7	5
India		11	13	13	16	18	19	20	22
France		9	15	10	7	13	13	11	14
German Federal Republic		14	18	16	12	14	16	18	17
Japan		14	16	22	22	15	21	25	38

(a) Estimated—include countries not shown and stocks afloat
(b) Excluded government stocks
(c) Little information available, a constant estimate of 75
Source: *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A10
Synthetic Rubber
End of Year Stocks

		1959	1960	1961	1962	1963	1964	1965	1966
Total (a, b)	'000 tons	335	407	435	465	522	577	615	677
of which in:									
UK		10	16	18	21	24	29	29	25
US(b)		211	249	256	262	283	297	312	348
Canada		9	10	17	19	17	18	24	28
France		9	18	30	18	27	34	42	55
German Federal Republic		10	9	8	9	9	10	12	9
Japan		10	17	22	28	38	34	39	46
Australia		4	5	5	8	8	7	3	7
India		1	3	3	3	10	11	7	8

(a) Estimated—Includes countries not shown and stocks afloat
(b) Excluding government stocks
Source: *Plantation Crops*, Commonwealth Secretariat, 1967, No. 11

Table A11
Rubber
Prices in Selected Countries

Year and Month	NATURAL											SYNTHETIC
	Wholesale prices						Export prices			Import prices		Wholesale prices
	Ceylon Rupees/100 lb.	Thailand Bahts/60 kg	UK Pence/lb.	US I Cents/lb.	US II	US III	Indonesia Rupiah/100 kg	Singapore I Cents/lb.	Singapore II	UK I Pence/lb.	UK II	US Cents/lb.
1960	123·7	756	32·2	38·2	37·6	34·9	4,070	108·1	104·9	30·6	28·6	23·9
1961	100·4	560	24·8	29·5	29·2	26·3	3,480	83·5	81·8	24·0	20·3	23·9
1962	97·8	508	23·3	28·6	27·9	26·6	9,182	78·2	75·8	22·4	20·5	23·6
1963	92·7	473	21·8	26·3	25·6	24·4	19,621	72·4	70·6	20·9	19·3	23·0
1964	89·5	454	20·6	25·2	24·9	22·3	37,990	68·1	67·2	19·8	18·3	23·0
1965	91·4	476	21·2	25·7	25·2	19·2	...	70·0	68·6	20·3	16·0	23·0
1966	89·1	449	19·8	23·6	23·3	22·5	...	65·4	63·8	19·1	—	23·0
1966 iv	90·4	470	20·0	24·5	24·3	23·2	...	67·3	66·0	19·8	—	23·0
v	91·5	464	21·1	24·2	24·0	24·3	...	68·7	66·2	19·7	—	23·0
vi	88·5	442	20·9	23·7	23·4	23·1	...	65·7	63·2	18·8	—	23·0
vii	88·7	444	20·0	23·5	23·2	22·5	...	64·6	63·2	18·8	—	23·0
viii	87·8	437	19·3	23·0	22·8	22·6	...	63·6	62·1	18·6	—	23·0
ix	84·6	413	18·1	22·2	21·8	21·4	...	59·7	58·8	17·7	—	23·0
x	88·0	430	19·1	22·0	21·6	21·2	...	62·7	61·2	18·2	—	23·0
xi	87·3	427	18·6	22·3	22·1	21·5	...	62·7	61·4	18·3	—	23·0
xii	85·3	412	18·4	22·0	21·8	21·2	...	60·3	59·3	17·8	—	23·0
1967 i	84·5	...	18·2	21·6	21·3	21·1	...	59·2	58·2	17·6	—	23·0
ii	81·2	...	17·6	20·7	20·4	19·8	...	56·8	55·8	16·9	—	23·0
iii	81·1	...	17·1	20·7	20·4	19·1	...	56·7	55·5	16·7	—	23·0
iv	81·9	...	17·0	20·8	20·5	19·0	...	57·1	55·3	16·7	—	23·0
v	80·1	...	17·1	20·7	20·4	18·4	...	56·1	52·9	16·0	—	22·8
vi	81·6	...	19·0	21·8	21·2	18·8	...	57·1	53·8	16·1	—	22·8
vii	79·3	...	18·2	20·6	20·0	18·8	...	55·4	52·8	15·8	—	22·8
viii	...	...	16·1	19·4	18·8	17·2	...	52·0	49·6	15·1	—	...
ix	...	...	...	...	...	...	...	50·7	47·5	...		...
x	...	...	...	...	...	...	...	50·2	46·2	...		...
xi	...	...	...	...	...	...	...	49·2	45·3	...		...
xii	...	...	...	...	...	...	...	49·6	45·7	...		...
1968 i								48·2	44·9			
ii								45·4	43·5			
iii								49·4	45·1			
iv								49·8	...			
v								51·4(p)				

(p) Provisional . . . Data not available — Nil or negligible or no longer applicable

Source: Compiled from *FAO Monthly Bulletin of Agricultural Economics and Statistics,* 16 No. 11, November 1967, 17 No. 6, June 1968, 17 No. 7/8, July/August 1968

Types of rubber for which prices are listed:

NATURAL RUBBER

Wholesale: CEYLON, RSS1, wholesale price excluding export duty, Colombo
THAILAND, Para, wholesale price Bangkok
UK, RSS1, Spot, London
US, Wholesale price, New York, I RSS1, II RSS3, III No. 3 Blanket Crepe

Export: INDONESIA, Sheets No. 1, prices f.o.b. Jakarta
SINGAPORE, In bales, f.o.b., I RSS1, II RSS3

Import: UK, c.i.f. London, I RSS3, II C blankets

SYNTHETIC RUBBER

Wholesale: US, S-type cold, staining and non-staining Nos. 1500 and 1502, f.o.b. plant.

Tropical Products Institute

G48

WORLD PRODUCTION AND TRADE IN FRESH GRAPEFRUIT

Tropical Products Institute
56/62 Gray's Inn Road
London WC1

Ministry of Overseas Development

May 1970

G48 WORLD PRODUCTION AND TRADE IN FRESH GRAPEFRUIT

Jacqueline Stother

ACKNOWLEDGEMENTS

The Institute acknowledges with gratitude the assistance given by users of grapefruit and members of the trade in the preparation of this report.

WORLD PRODUCTION AND TRADE IN FRESH GRAPEFRUIT

TABLE OF CONTENTS

Page

List of Tables

List of Figures

6. The grapefruit industries of five countries (the United States, Israel, South Africa, Argentina and Cyprus) and the Caribbean area are discussed. Production is increasing in all areas apart from the Caribbean, where in general old and diseased trees are not being replaced. Grapefruit is grown principally for export as fresh fruit in relatively few countries: viz Israel, South Africa and Cyprus.

7. International trade in fresh grapefruit is discussed. Trade in fresh grapefruit has shown a strong upward trend since 1957. Exports recorded an increase of 120 per cent between 1957 and 1967, exceeding 334,000 tons in the latter year. Israel took over the position of major world exporter of grapefruit from the United States in 1964. Exports from South Africa and Cyprus have risen strongly, as have those from some minor producing countries, such as Spain and Dominica; however exports from Trinidad, Morocco and Jamaica, have declined. (see Table 1, page 14).

8. The export trade structures of and trends in exports from eleven countries (Israel, United States, South Africa, Cyprus, Trinidad, Morocco, Spain, Jamaica, Surinam, Brazil and Dominica) are discussed. A distinction is drawn between countries having national export organisations either State, or co-operatively-owned (Israel, South Africa, Morocco and most of the Caribbean countries) and those countries relying on private exporters (United States, Spain, Brazil and Cyprus).

9. The major import markets for fresh grapefruit are the United Kingdom, Canada, the member countries of the European Economic Community (EEC) and Switzerland. This is in marked contract to the pre-War situation when the United Kingdom and Canada were the only large importers of grapefruit. These two countries are still the major import markets, but imports into the EEC countries have increased very rapidly in recent years. Imports into the Scandinavian countries are of minor importance and show a slower rate of increase than imports into most other European countries.

10. The import situation in ten major markets (the United Kingdom, Canada, Germany, France, Netherlands, Belgium/Luxembourg, Switzerland, Italy and Scandinavia) is analysed on the basis of annual and monthly trade statistics. Most importing countries show a relatively low level of imports during the months June to October and a particularly low level in August, September and October.

11. Virtually all Canadian imports of grapefruit are supplied by the United States - also an important supplier to most continental European markets, especially France. The United Kingdom imports very limited quantities of grapefruit from the United States and relies largely on imports from Israel (the dominant supplier of European markets), Cyprus and South Africa. Among the minor suppliers; Mozambique, Swaziland and the West Indies also supply this market. The Honduras Republic is of importance as a supplier to the German, French and Dutch markets and the last named also receives substantial quantities of grapefruit from Surinam.

12. Quality and packaging requirements for international trade are assessed. The standards for imports into the EEC and the United States are set out in Appendices A and B. Grapefruit should have a well-coloured, unblemished skin and preferably a shelf-life of one month or more in the importing country. On the whole "desert" grapefruit meet these conditions better than do "tropical" grapefruit. European consumers prefer smaller grapefruit than North American consumers and this again creates problems for exporters of large tropical fruit.

13. Barriers to trade in the form of quotas, import tariffs, taxes and phyto-sanitary regulations are examined. Only the United Kingdom imposes quotas - on imports of grapefruit from the Dollar Area, with a complete prohibition of imports of fruit from the Dollar Area (other than Cuba) in October and November. Rates of import duty are moderate - ad valorem rates will be reduced to 6 per cent or less by 1972 and several countries will then grant free entry to grapefruit imports (see Table 3, page 53). Internal taxes levied on grapefruit range from nil in Switzerland and the United Kingdom to 14 per cent of gross landed value in Belgium; however these taxes are generally levied on all goods so that the price of grapefruit relative to other products is not affected.

14. Only the phyto-sanitary regulations of Italy and the United States are restrictive. However waivers to the Italian regulations may be applied for fumigation of fruit may be necessary to comply with the strict American regulations.

15. In Part III the different market structures, demand patterns and price levels in the major world markets for grapefruit (United States, Canada, United Kingdom, Germany, France, Netherlands, Belgium, Switzerland, Italy and Scandinavia) are discussed.

16. Per capita consumption is highest in the United States and Canada where it has reached 9 lb per annum. In Europe however per capita consumption is much lower; the highest levels reached - in the United Kingdom and Switzerland, are less than 4 lb per capita. Nevertheless consumption in many European countries has increased very rapidly in recent years, for instance per capita consumption of grapefruit doubled between 1963 and 1968 in Germany and France to reach 2.8 lb and 2.4 lb per head, respectiv Consumption in Italy and the Scandinavian countries however is relatively low (below 1.5 lb per capita), although Italian consumption has risen very rapidly since 1964 from a very low base.

17. Average import values for grapefruit, over the six years 1963 to 1968 were calculated from the trade returns of Canada, the United Kingdom, Germany, France, Netherlands, Belgium/Luxembourg, Switzerland and Italy. There has been no overall trend in these values.

18. Monthly average wholesale price series were available for the United Kingdom and France, as was an average "on-tree" price series for the United States. The two wholesale price series show that prices are at their lowest during the winter and early spring months and rise during the summer months to a peak in September or October (this pattern was not followed in 1969 when there was a shortage of supplies during late spring and early summer). The American "on-tree" prices also follow this pattern on the whole, but frost damage to the crop sometimes causes prices to rise in early spring.

19. The traditional fruiterers shop still retains its importance as a retail outlet for grapefruit in the United Kingdom although in North America the independent retailer has been almost entirely supplanted by supermarkets and chain stores. In continental European countries, chain stores and supermarkets were instrumental in introducing grapefruit to consumers in the post-War period, and are probably the major outlets for grapefruit on these markets. Catering outlets appear to be of importance only in the United Kingdom.

20. Part IV of this report discusses estimates of future production, export availabilities and consumption of grapefruit for 1975. FAO estimates put production at 3,560,000 tons and export availabilities at about 900,000 tons in that year, while import demand (for Canada and Western European countries) was estimated at only 402,000 tons.

21. More recent information suggests that export availabilities in 1975 are unlikely to exceed 600,000 tons and projections of import demand for that year made by TPI total 492,400 tons.

22. Various other factors may reduce the discrepancy between export availability and import demand for grapefruit; for example United States crops may be reduced by frost damage and the East European countries may become regular buyers of grapefruit.

23. The above estimates for consumption have been made on an annual basis. However the level of imports during the months July to October is generally much lower than during the other months of the year, despite the fact that the warm weather during the summer and early autumn months might be expected to stimulate demand for grapefruit. In addition, wholesale prices in the United Kingdom and France are high during this period, which also suggests that larger quantities of grapefruit could be sold at this time, if they were available.

24. At present South Africa is the only large supplier of world markets during these months and the bulk of her crop is harvested by July. Thus most grapefruit on world markets in September and early October (before the commencement of the Northern Hemisphere season) has been cold-stored, apart from small quantities exported from Jamaica, Dominica and other Caribbean countries.

25. The present unsatisfied demand for fresh grapefruit during the months July to October is estimated at about 25,000 tons for Canada and the Western European countries together, of which 14,500 tons would be required in September and the first two weeks of October. On a less conservative basis unsatisfied demand in these countries may be estimate at 50,000 tons. Furthermore the United States might absorb 50,000 tons of imported fruit over the period June to September, if exporting countrie could comply with her strict phyto-sanitary regulations.

26. The supply gap identified above may be affected by unforeseen factors; for example the problems of long-term cold-storage of grapefruit might be overcome, so that Israeli and even Florida grapefruit could be markete over a much longer period, while South African supplies could be increase in September and early October.

27. An increase in supplies during September and October would almost certainly reduce prices to some extent, however the precise result is impossible to calculate. Good quality grapefruit would be expected to fetch a premium over cold-stored fruit.

28. It is concluded that providing a new suppliers' grapefruit can satisfy requirements of appearance, intrinsic quality, shelf-life and regularity of supply, it should find a good market in Canada, the United Kingdom and the EEC countries during the July to October period, when these markets appear to be under-supplied to the extent of some 25,000 tons. Although the United States also provides a large potential market from June to September, her phyto-sanitary regulations may prove prohibitive. The projected increase in demand for grapefruit during the period end-October to June will easily be met by projected increases in production in Israel, the United States, Cyprus and (to some extent) South Africa.

WORLD PRODUCTION AND TRADE IN FRESH GRAPEFRUIT

PART I - PRODUCTION

World Production

The grapefruit (*Citrus paradisi* Macfadyen) has been cultivated on a commercial scale only since the eighteen-eighties when the first orchards were established in Florida. Production was established in many other countries such as Jamaica, Trinidad, South Africa and Israel during the inter-war years, but the United States remained the dominant supplier, accounting for over 90 per cent of the world crop on average during this period. In the 1945/6 season US production exceeded 2,285,000 tons, a level which has never been attained since that time, because of severe frost damage in the winters of 1948/9 and 1950/1 which virtually destroyed the Texas citrus industry.

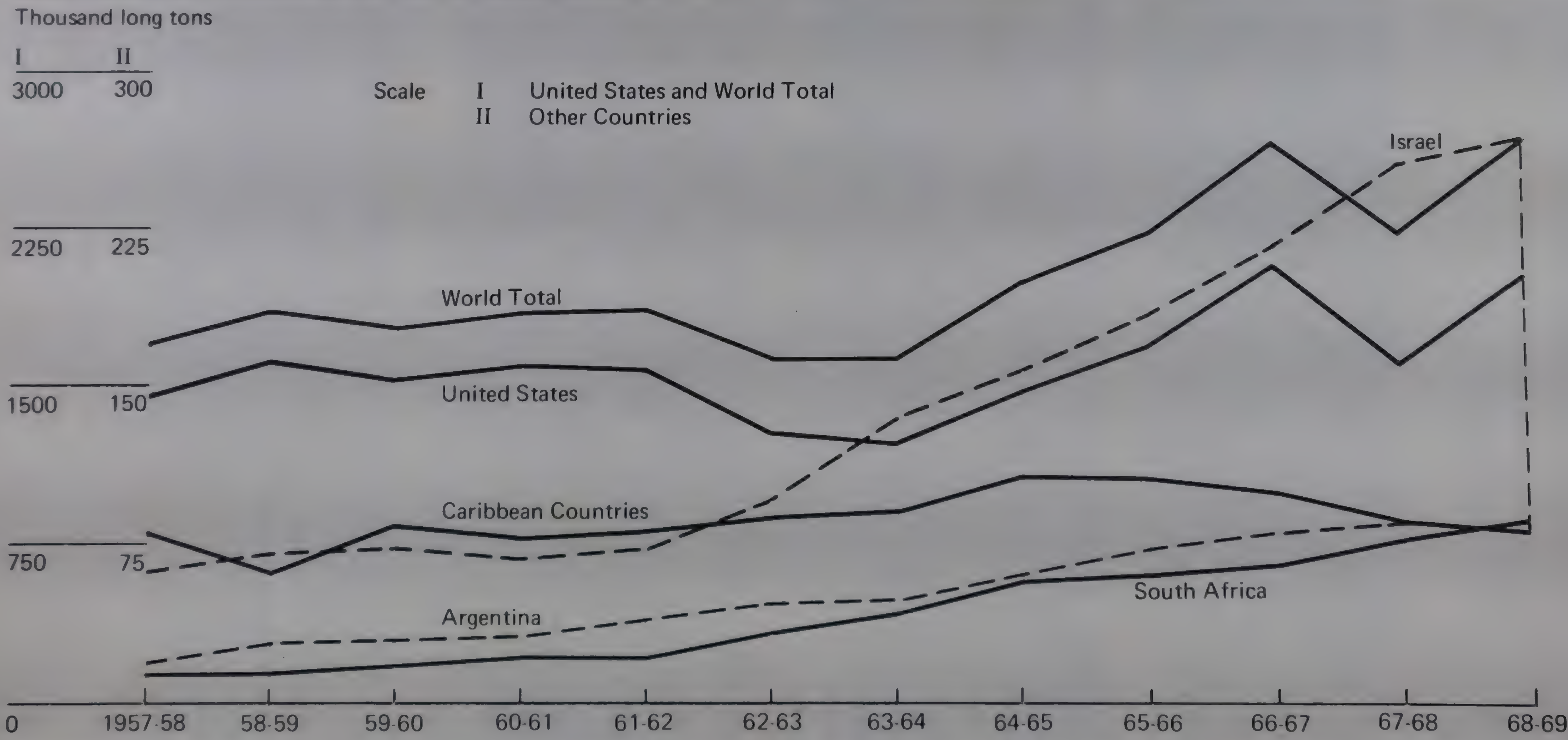
In spite of steadily increasing grapefruit production in other countries, the world crop did not exceed the record U.S. crop of 1945/6 until 1966/7. The ten seasons 1957/8 to 1966/7, saw a sixty per cent increase in production from 1,614,000 tons to 2,639,000 tons despite a set-back in the 1962/3 and 1963/4 seasons following further frost damage to the United States' crop. Production is estimated to have declined slightly in 1967/8 (to 2,234,000 tons), but estimated production for 1968/9 is 2,630,000 tons (See Table I in Appendix D). The upward trend in production is expected to continue as new plantings in the United States, Israel and Cyprus come into bearing and the FAO has estimated that production may reach 3,560,000 tons by 1975, representing a thirty-five per cent increase over the 1966/7 crop. (1)

Figure 1 on page 2 demonstrates that in spite of repeated frost damage to the United States' crop (in the winters of 1957/8, 1962/3 and 1966/7), and rapid expansion of grapefruit production in other countries, the United States is still the dominant producer of grapefruit, accounting for 85 per cent or more of world production during the period 1957/8 to 1961/2 and for 78 per cent of world production, on average, from 1962/3 to 1966/7: in 1967/8 the United States' share of world production fell to 70 per cent. Israel, the world's second grapefruit producing country, accounted for only 8 per cent of world production in 1966/7 (11 per cent in 1967/8) or less than 11 per cent of the United States' crop in that year, in spite of a 250 per cent increase in the Israeli crop during the ten years 1957/8 to 1966/7.

Other major producing countries are the Republic of South Africa and Argentina: these countries' crops increased by 360 per cent and 300 per cent respectively during the ten years 1957 to 1966 and in the latter year their crops accounted for 3 and 4 per cent respectively of the world total. The Caribbean area as a whole is a significant supplier of grapefruit, but after a 38 per cent increase in production over the period 1957/8 to 1964/5 from 78,000 tons to 108,000 tons, production declined, being only 86,000 tons - 4 per cent of the world total in 1967/8 compared with 5 per cent of world production in 1957/8.

Figure 1
Grapefruit World production 1957-8 to 1968-9

Sources: See Table 1



Minor producers include Cyprus, Morocco, Spain and Algeria in the Mediterranean region; and in the Southern Hemisphere, Mozambique and Swaziland, Brazil and Australia. There is some production in Asia and New Zealand both of true grapefruit and also of grapefruit-like hybrids.

Since a large proportion of the world grapefruit crop is produced in the United States, where there is a large usage for processing, the proportion of grapefruit consumed in fresh form is much smaller than those of the other major citrus fruits such as oranges and lemons. In recent years about half the United States crop has gone to processing, while in some Caribbean countries, notably British Honduras, and Jamaica, a major proportion of grapefruit production is processed. However in most other producing countries grapefruit is grown for the fresh export trade or the domestic market and only the culls are processed.

The proportion of fresh grapefruit entering international trade is also small in comparison with oranges, for example, because of the dominance of the United States' grapefruit industry, which exports only a small percentage (between 5 and 10 per cent) of production in the fresh state. Production in Argentina, one of the major producers, is also almost entirely for domestic consumption. The countries producing grapefruit specifically for export as fresh fruit - namely Israel, South Africa and Cyprus - accounted for only 17 per cent of world production in 1967/8.

Commercial Varieties

Most varieties of grapefruit grown commercially originated in Florida, where the fruit was first successfully cultivated on a large scale. The grapefruit is unusual in that only two or three varieties are widely planted on a commercial scale and these varieties can be grown in all grapefruit producing areas, although their flavour and other characteristics vary according to the climatic conditions (this point will be pursued later).

Connoisseurs generally agree that the flavour of seedy grapefruit is stronger and more pronounced than that of the so-called seedless varieties. Since the former also mature earlier and exhibit better section stability in canning, many processors prefer the seedy fruits. The principal seedy grapefruit in commercial production is the Duncan which is described below:-

Duncan: Fruit large and oblate, from $3\frac{1}{2}$ to 5 inches (90mm to 125mm) in diameter. Skin colour pale to light yellow. Rind medium-thick and surface smooth and even. Flesh buff-coloured; tender, very juicy; flavour pronounced and excellent. Contains up to 50 seeds. Medium-early in maturity. (2)

Marsh Seedless

The first commercial "seedless" grapefruit variety (containing few or no seeds) was the Marsh Seedless which became available in 1889. Because of its highly desirable seedless characteristic, it attained dominance in Florida within a few decades and became the leading grapefruit variety of the world - a status it has retained ever since. It has the following characteristics: Fruit medium in

size, oblate to spherical, from 3 to 5 inches (75mm to 125mm) in diameter. Skin colour pale to light yellow. Rind medium-thin, tough; surface very smooth and even. Flesh buff-coloured, tender, very juicy; flavour good though not so pronounced as in some seedy varieties. The latest-maturing of all commercial varieties. (3)

Various pigmented varieties of grapefruit have been developed, the first of these, a seedy variety, being discovered in 1907 and named the Foster Pink. During the nineteen-twenties two seedless pigmented varieties were found - Thompson, a pink-fleshed limb sport of a Marsh Seedless tree and, a little later, a red-fleshed sport of Thompson, known as Redblush or Ruby. The Thompson was planted extensively in Texas and Florida, but later lost in popularity to the deeper coloured Redblush which has an attractive pink blush on the rind. It appears that heat is a requisite for colouration of pigmented grapefruit as the colour is most intense in grapefruit grown under the hottest climatic conditions. (4) Since the natural colour of the pigmented varieties is difficult to retain during processing, these varieties are largely restricted to fresh fruit outlets.

Thompson (Pink Marsh): Fruit medium in size, oblate to spherical. Skin pale to light yellow. Rind medium thin, tough and surface very smooth. Flesh colour under favourable conditions light pink (but not in the juice); albedo not pigmented; flesh texture tender and juicy; flavour good, similar to Marsh. Holds on tree well but with considerable fading of colour. Midseason in maturity (earlier than Marsh). (5)

Redblush (Ruby): Fruit similar to Thompson except for much deeper pigmentati in the flesh (but not in the juice); crimson blush on rind, especially at points of contact between fruit, albedo pigmented. (6)

Varieties of citrus hybrids resembling grapefruit which are of local importance include the Natsudaidai or summer orange of Japan, where it accounts for some 15 per cent of citrus production; the New Zealand grapefruit or Poorman orange which is also grown in Australia and is the major citrus fruit produced in New Zealand, and the Wheeny grapefruit - also of importance in New Zealand. These three citrus varieties have heat requirements lower than the grapefruit and are of commercial importance chiefly in areas where grapefruit will not ripen satisfactorily. (7)

Climatic types

Reference was made above to the fact that climatic environment affects the characteristics of grapefruit in a striking manner. Under hot desert conditions (little rainfall and that during the winter months only) the skin colour is brighter and deeper and the flavour sharper than in humid climates, and the fruit is of somewhat smaller size, less oblate form and lower juice content. Grapefruit grown under humid tropical, or sub-tropical, conditions (heavy rainfall distributed throughout the year) tend to have thin, blemished skins, which are frequently a greenish colour at maturity because the cool temperatures required to colour the fruit are lacking. (8)

The differences between "desert" and "tropical" grapefruit are sufficiently great to constitute a natural trademark, and to provide the markets with fruit to meet a variety of tastes and preferences. The distinctions most often drawn between the two types are that desert grapefruit have a more attractive outward appearance and a longer shelf life, while tropical grapefruit are juicier and have a finer flavour.

Grapefruit Production In Selected Countries

The United States

The United States is the leading world producer of grapefruit and the volume of the world crop is largely determined by the quantity of fruit harvested in the State of Florida. The bulk of the United States crop is harvested during the period October to April, but the US is unique amongst major producing countries in that grapefruit is available from at least one production area at all times of the year, the official harvesting seasons being as follows:- (9)

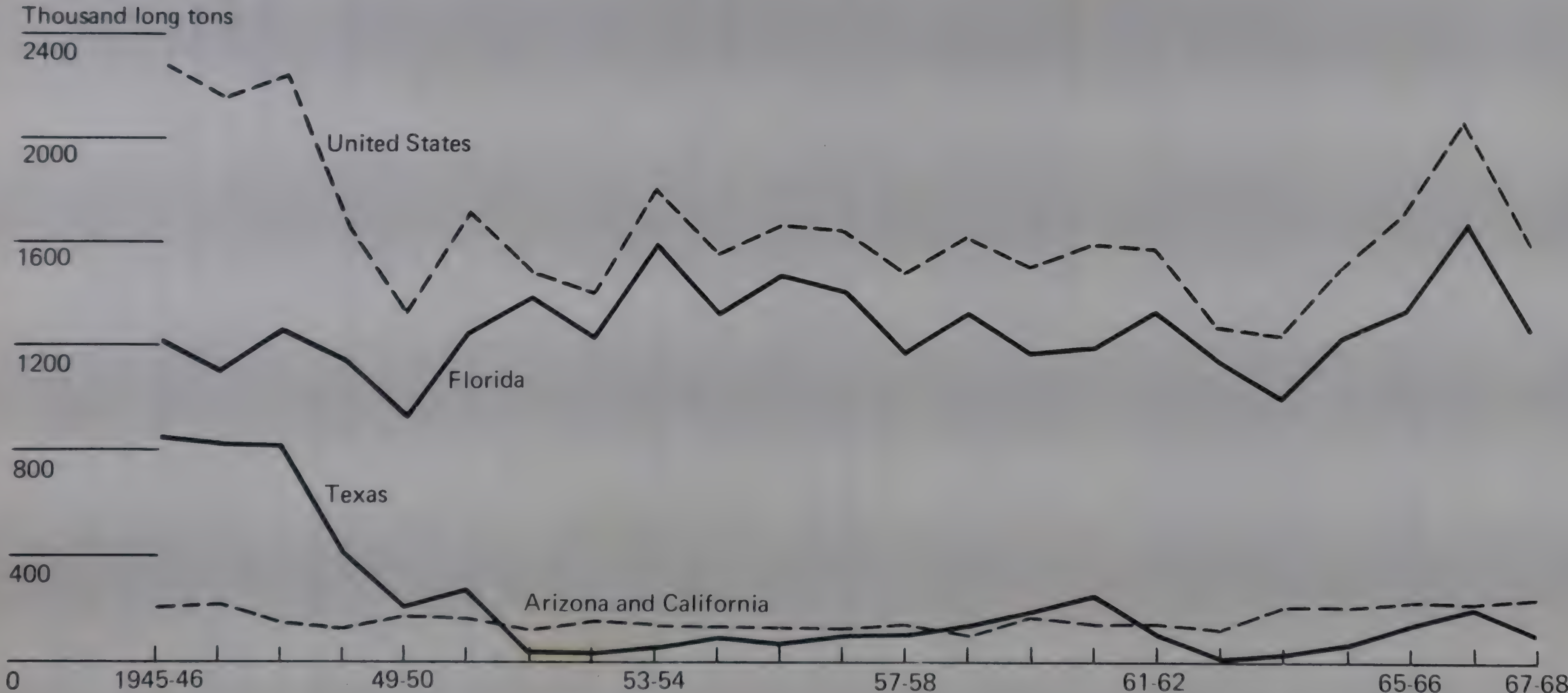
Florida	September 5th to June 10th
Texas	September 25th to May 30th
Arizona	November 1st to July 31st
California Desert Valleys	November 15th to July 15th
Other Areas	March 25th to October 31st

The trend of production of grapefruit in the United States is shown in fig. 2 on page 6 . The peak of production, approximately 2,285 thousand tons, was reached in the 1945/6 season, shortly before the devasting frosts of 1948/9 which reduced production drastically, notably in Texas. Frost damage at fairly frequent intervals since that time checked any expansion of production until recent seasons - in 1966/7 the grapefruit crop again exceeded 2,000 thousand tons. The State of Florida is the major producing area in the United States, and since the 1948/9 season has accounted for at least eighty per cent of US production in most years, as shown in Fig. 2. The other producing areas, Texas, California and Arizona, supplied 6,8 and 7 per cent respectively of the total crop in the 1967/8 season.

Total U.S. production has shown an upward trend since the hard winter of 1962/3, apart from a decline in 1967/8 when production in Florida suffered from cold weather during flowering and the crop in Texas was halved by hurricane damage. Production in 1968/9 recovered to close on 2,000 thousand tons and FAO projections, based on newly planted acreage, estimate that production will reach 2,500 thousand tons by 1975, an increase of twenty-five per cent over the 1968/9 crop. (10)

The total acreage in the United States planted to grapefruit will not be known until the results of a tree census in Texas are published. However in December 1967 bearing acreages in the other productng states were 6,700 acres in Arizona, 12,800 acres in California and 87,500 acres in Florida; in addition there were 32,400 acres in Florida of newly planted grapefruit not yet in bearing ie less than 4 years old. (11) Thus unless considerable areas of old orchards are grubbed out, the bearing acreage of grapefruit in

Figure 2
Grapefruit U.S. production by States 1945-6 to 1967-8



Source: Florida Agricultural Statistics, Citrus Summary, 1964 and 1968 issues, Florida Department of Agriculture.

the United States seems likely to increase rapidly over the next few years, while an even larger proportion of the total acreage will be in Florida.

As regards the types and varieties of grapefruit produced in the United States, white seedless varieties, notably the Marsh Seedless, are probably of greatest commercial importance, certainly in California and Arizona. A large proportion of the Texas crop is understood to be of seedless red-fleshed varieties which have also been of increasing importance in Florida. Finally there is still a substantial acreage of seedy grapefruit (white-fleshed) in Florida which is now used almost entirely for processing. Grapefruit grown in California and Arizona are of the desert type, whereas Florida and Texas grapefruit have the characteristics of tropical fruit.

A high proportion of grapefruit produced in the United States is processed into juice, canned or frozen segments etc, most particularly in Florida. In 1967/8 approximately 790,000 tons of grapefruit were processed, representing fifty per cent of the total crop, the percentage of fruit processed in each area varying from 55 per cent in Florida to 18 per cent in Texas. (12) The proportion of the crop processed depends largely on the size of the crop. Since demand for the fresh fruit remains relatively constant, in good crop years there is a larger volume of fruit surplus to the requirements of the fresh fruit market and consequently a larger proportion of the crop is available for processing. On the other hand if the crop is damaged by frost a large proportion may be processed, even though the crop is a poor one, because frost-damaged fruit may be suitable for juicing although not for the fresh market.

As regards the varieties of grapefruit used for processing, data is available only for Florida where 51 per cent of white seedless grapefruit, 26 per cent of pink seedless and 91 per cent of seedy grapefruit were processed during the 1967/8 season; these types accounted for 40 per cent, 14 per cent and 46 per cent respectively of the total tonnage of grapefruit processed in that season. (13)

Although the United States was the world's major exporter of grapefruit prior to 1965 and still takes second position after Israel, exports of fresh grapefruit are a very minor outlet for United States production, amounting to less than 115,000 tons, or approximately six per cent of total US production in 1967 and 79,000 tons, or five per cent of production in 1968. Exports will be discussed more fully in Part II.

Israel

The normal harvesting season in Israel extends from mid-October until the end of March, although harvesting may begin as early as the end of September in the earliest production areas of the Jordan valley.

Although Israel supplied only 11 per cent of the world crop in 1967, she is the second largest world producer of grapefruit and her production increased by more than 300 per cent over the period 1957 to 1967, from 62,000 tons to

256,000 tons (see Table I of Appendix D). According to the FAO, Israel's production of grapefruit increased at an average rate of 19.4 per cent per annum over the period 1958/9 - 61/2 to 1965/6 - 66/7, but their projections suggest that the rate of increase will fall to an average of 6.1 per cent per annum to yield a production of 320,000 tons in 1975. (14)

The acreage in Israel planted to grapefruit rose from 2,800 acres in 1950 to 12,900 acres in 1962 and was estimated at 16,000 acres in 1969. However much of this acreage is not yet fully bearing; for example in 1964, of the 15,400 acres planted, only 4,200 acres were fully bearing and 8,000 acres were in partial bearing ie less than 7 years old. (15) It was reported that grapefruit plantings were "frozen" for four years from 1963 (16) but new planting now appears to be proceeding where suitable land is available. Howeve Israel is a small country and irrigation is necessary to produce good crops, so the area of irrigable land and competition from other crops are factors limiting expansion of the acreage of grapefruit. Citrus is grown chiefly on the coastal strip, but there are some plantings of grapefruit in the Jordan valley, where the fruit ripens early.

Grapefruit grown in Israel are intended chiefly for export as fresh fruit. However only top quality fruit is exported, the inferior grades being sold on the domestic market or used for processing. In 1966/7, when the crop amounted to 222,000 tons, 122,000 tons or 55 per cent was exported fresh, 74,000 tons (33 per cent) used for processing, and domestic consumption of fresh grapefruit amounted to 26,000 tons. (17)

There has been a trend towards increased processing of grapefruit; in 1958/9 for example, when production amounted to only 70,000 tons, 66 per cent was exported fresh and only 18 per cent used for processing. (18)

Israel grapefruit is almost exclusively of the Marsh Seedless variety and is of the desert type. The fruit is generally considered to be of good eating quality and to have a long shelf-life.

<u>Republic of South Africa</u>

South Africa is one of the two major producers of grapefruit in the Southern Hemisphere, the other being Argentina. Harvesting extends from mid-March until the end of August.

In common with many other producing countries, grapefruit production in South Africa has shown a very rapid rate of increase from only 14,000 tons in 1957 to about 76,000 tons in 1967; in fact production trebled between 1961 and 1967 (see Table I of Appendix D). FAO projections estimate production in 1975 at 125,000 tons.

Grapefruit acreage figures are not available for South Africa and the most recent data concerning tree numbers are for 1960, when there were 762,000 grapefruit trees, only 300,000 of which were fully bearing ie more than 6 years old (19); this compares with 267,000 trees, two-thirds being fully bearing, in 1950. However there has been little new planting of grapefruit in recent years and production is expected to rise chiefly by virtue of higher yields, which are expected to increase from an average of 190 lb. per tree in 1960 to 210 lb per tree by 1975. (19) There are two major production areas in South Africa - the East Transvaal, which is the more important and supplies grapefruit from mid-March to June, and the Cape (where after five years of drought, production is limited) where harvesting takes place from July onwards.

Swaziland is often considered part of the South African citrus industry, since citrus produced in Swaziland is sold through the Outspan organisation (see page). Planting in the latter country has increased rapidly. In 1965 approximately 2,600 acres were planted to grapefruit, 72 per cent of the trees being less than four years old (ie non-bearing) and 26 per cent being between four and six years old (partially-bearing). (20) Citrus grown in South Mozambique is also sold by the Outspan organisation, but acreage figures are not available.

Grapefruit produced in South Africa are largely of the Marsh Seedless or similar varieties, although there is limited production of the Redblush variety. South African grapefruit is of the desert type.

The South African grapefruit industry is also geared to the export of fresh fruit; the domestic market is relatively small, but a substantial tonnage is used for processing (21). Red-fleshed varieties of grapefruit are not accepted by processors, and although they are apparently favoured on the domestic market, they form only a small proportion of exports of fresh grapefruit (4 per cent in 1968). (21)

Argentina

Production in Argentina has also shown a rapid increase, from 20,000 tons in 1957 to 85,000 tons in 1967, and the FAO estimates that production will reach 100,000 tons by 1975. These figures are for marketed production only; total production was estimated at 110,000 metric tons in 1968. (22) Argentina is the only major producer of grapefruit in South America but production appears to be entirely for domestic consumption. Exports have been negligible in recent years, only 200 to 300 tons being exported per annum. Small quantities of fruit are used for processing.

Cyprus

Cyprus is the second largest producer of grapefruit in the Mediterranean region. The harvesting season is slightly earlier than that in Israel extending from early October until February. Production of grapefruit has risen rapidly from 8,000 to 9,000 tons in the period 1957 to 1960 to 35,000 tons in 1967. FAO projections estimate the 1975 crop at 45,000 tons.

There is no data available concerning the acreage planted to grapefruit but the total area of citrus cultivation is estimated at 32,000 acres (23) and it is understood that new plantings are being made wherever irrigated land is available.

Virtually the only variety of grapefruit grown in Cyprus is the Marsh Seedless, which is scarcely surprising considering the importance of fresh grapefruit exports - in 1966/7 26,000 tons, or 84 per cent of the crop was exported and only 6 per cent was used for processing. Cyprus grapefruit is of the desert type and is generally considered to be of very good quality.

The Caribbean

Although the individual countries of the Caribbean are relatively minor producer of grapefruit, the area as a whole is an important supplier. All the producing areas of the Caribbean (this term includes Surinam, Honduras and British Honduras) lie within the tropics and the grapefruit produced shows the typical characteristics of tropical fruit.

Harvesting of grapefruit may be virtually year-round under tropical conditions when flowering is initiated by rains following a dry period. Nevertheless, in general there is a primary bloom and hence a primary harvesting period. However under sub-tropical conditions such as obtain in British Honduras, blooming is controlled by both temperature and rainfall and there may be two crops in a year.

The Caribbean area is an exception to the general rule of rapidly increasing production of grapefruit, for in spite of an upward trend in many of the smaller producing countries, Trinidad, one of the largest producers, has actually shown a downward trend in commercial production over the last few years while Jamaican production also declined during the last two seasons. Production in some of the more important countries of the Caribbean is described below.

Jamaica

The Jamaican grapefruit industry began during the inter-war years, and before the Second World War was already a substantial supplier of fresh grapefruit to international markets. Commercial production rose to a peak of 37,000 tons in 1966/7 but since then production has fallen to 22,000 tons in 1968/9. The acreage planted to grapefruit is probably declining as old trees are not replaced; in 1958 3,600 acres were planted to grapefruit but the acreage had fallen to 3,000 acres by 1962. (24)

Marsh Seedless is the most important variety grown and there is also some production of a local sweet seedy grapefruit which is used exclusively for the domestic market; other seedy varieties, such as Duncan, are used for processing.

The bulk of commercial production of grapefruit is processed - about 72 per cent in the 1967/8 season (25), and domestic demand is also strong - in recent years less than 10 per cent of the crop has been exported as fresh fruit. The export season begins in September and may extend until February, although most shipments are made before the end of December.

Trinidad

Trinidad has also been an important producer of grapefruit since before the Second World War. The latest acreage estimates are for 1958 when 5,800 acres were planted to grapefruit; however most grapefruit trees are old and are not being replaced (24). Commercial production has fluctuated considerably since 1957 from the 35,000 tons of 1959 and 1964 to the 18,000 tons of 1958 and 1967. Unless replanting takes place the downward trend of the last four seasons is likely to continue.

Varieties of grapefruit grown in Trinidad include Marsh Seedless, Duncan and a few Foster Pink.

A large proportion of the crop is processed into canned juice or segments (about 85 per cent in the 1967/8 season (25)) and a relatively small proportion of the grapefruit crop is exported fresh (21 per cent in 1966/7 and 12 per cent in 1967/8 (25)). The export season is late compared with that in many parts of the Caribbean, usually extending from January to April. Trinidad grapefruit is smaller than is usual for tropical fruit and meets the size requirements of European markets.

British Honduras

Before the Second World War the commercially important citrus plantings in British Honduras were largely of grapefruit. In 1962 grapefruit acreage amounted to 1,600 acres, not all of which was in bearing. (26) Production (ie in this case quantities delivered to the canners and packing station) fluctuates considerably, but has not exceeded 11,000 tons in recent years, and has averaged about 9,000 tons over the last 5 seasons. British Honduras is subject to periods of drought and also to hurricane damage. Hurricane "Hattie" resulted in the loss of most of the 1961/2 crop and about 10 per cent of the grapefruit trees.

Nearly all grapefruit are of the Marsh Seedless variety with a few Duncan. In spite of the favourable export season (September and October) exports of fresh grapefruit have been sporadic in recent years, possibly because of a lack of shipping. A large proportion of the crop is processed. (25)

Surinam

Although Surinam is not, strictly speaking, in the Caribbean area but on the North Coast of South America, its citrus is of tropical quality and similar to that grown in the Caribbean area.

The citrus industry was established in Surinam during the nineteen-thirties and by 1960 the area planted to grapefruit was estimated at 855 acres of which 136 acres were non-bearing (27). Production reached 7,000 tons in 1962 and has remained at approximately this level since then.

Most grapefruit are of the Marsh Seedless variety and up to half the crop is exported as fresh fruit - Surinam is able to export grapefruit during every month of the year if climatic conditions are favourable. Although a processing industry was set up to produce frozen concentrated citrus juice in 1961, it closed down a few years later and it is understood that consequently a considerable part of the potentially exportable citrus fruit is being destroyed at present. (28)

Other Caribbean Countries

Grapefruit production is of importance in several other Caribbean countries for which little information concerning production is available, these include Puerto Rico, Cuba, Honduras Republic and Dominica. Grapefruit grown in Puerto Rico are primarily for domestic consumption but a significant proportio of the production in Honduras and Dominica is exported to Europe. Cuba has recently begun to export to Europe during the months of September to January and apparently is planning to increase exports. (29)

PART II - WORLD TRADE IN GRAPEFRUIT

World trade in grapefruit has seen a remarkable increase during the post-War period as the minor producing countries have expanded their export potential and the grapefruit eating habit has spread from the Anglo-Saxon countries to the countries of continental Europe.

Immediately before the Second World War Israel was the major exporter of grapefruit, followed by the United States and South Africa, while the United Kingdom was the major importer, followed by Canada. During the nineteen-forties many of the Israeli citrus groves were abandoned, the American crop rose to record levels and world trade was completely disrupted. After the War the United States took Israel's place as the major exporter of grapefruit and her chief market, Canada, was the major importer. Since the early nineteen-fifties the gradual relaxation of restrictions on imports (which were imposed by European countries in order to save dollars) and increasing production in Israel and Cyprus in particular, have permitted the very rapid expansion of grapefruit consumption, particularly in the EEC countries. The very low level of imports into these countries during the pre-War years may well have resulted from restrictive trade policies and reliance on bilateral trade agreements in those years.

Quality and packaging requirements for internationally traded grapefruit are exacting. For European markets the fruit should have a brightly coloured, unblemished skin, and as long a shelf-life as possible. These requirements make desert-type grapefruit better suited to European trade than tropical grapefruit. Outside North America outlets for red or pink-fleshed grapefruit are limited.

Import duties levied on grapefruit are generally quite low - in the range of 6 to 7 per cent - and when the Kennedy Round concessions are fully implemented in 1972 imports into some countries, eg the Scandinavian countries other than Norway, will be free of duty. Since grapefruit is not produced on a commercial scale in any EEC country, there is no reference price system for EEC imports. The chief barriers to trade are the United Kingdom's prohibition of imports from the Dollar Area during October and November, and the Italian phyto-sanitary regulations.

Exports

Total world exports of grapefruit have shown a steady upward trend, since 1957 (see Table 1 on page 14) broken only in 1963 as the result of frost damage to the Florida crop; however exports in 1964 recovered to a level exceeding that of 1962 and in 1967 world exports exceeded 330,000 tons compared with an annual average of less than 150,000 tons in 1957-59.

Until 1963 the United States was the largest exporter of grapefruit, supplying almost half world exports during the late nineteen-fifties. However in 1964 exports from Israel exceeded those of the United States, and by 1968 Israeli exports of 152,400 tons were nearly double American exports (which were probably affected by the small 1967/8 crop) (see Table 1 on page 14). Both

Table 1

Exports of Grapefruit from Principal Countries

	1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	196
Israel	*45,749	*52,353	64,529	82,256	91,201	110,545	121,949	152,
United States	73,205	89,923	70,990	73,914	87,497	95,790	114,871	78,
South Africa	10,823	17,416	20,587	31,983	34,182	47,094	46,743	56,
Cyprus	...	* 9,580	12,590	15,810	24,822	19,674	32,300	32,
Trinidad and Tobago	5,482	8,443	6,134	4,349	3,445	4,941	4,480	2,
Morocco	5,485	7,157	5,566	5,073	3,317	(5,600)	4,507	..
Spain	1,046	1,825	2,241	2,858	3,142	3,959	3,313	3,
Jamaica	2,120	2,960	6,056	3,116	4,065	1,604	1,630	2,
Surinam	...	* 3,956	3,458	1,751	2,489	2,979	...	..
Brazil	802	2,150	3,904	3,024	3,007	1,702	2,087	..
Dominica	...	895	749	1,293	1,200	1,710	2,486	2,
TOTALS (a)	*144,712	*196,658	196,804	225,427	258,367	(295,598)	334,366	..

... Information no available

( ) Unofficial estimate

(a) Totals of available figures

* Average of less than 3 years

Source: Trade Returns

Israeli and US fruit is exported largely during the months October to April (with the exception of small quantities of Californian summer grapefruit) but the third largest exporter, South Africa, is able to supply world markets during the period April to September, and exported approximately 56,800 tons in 1968. Cyprus is the only other major exporter of grapefruit, contributing 32,700 tons in 1968; her season extends from October until February.

Other minor suppliers include several Caribbean countries, notably Trinidad, Jamaica, Surinam, Cuba and Dominica; Morocco, Spain and Turkey in the Mediterranean; and Mozambique, Swaziland and Brazil amongst the Southern hemisphere suppliers.

Most exporting countries now have a central governmental or co-operative organisation which is responsible for handling all exports of citrus fruit. The major exception to this rule is the United States, but Brazil and Spain are two minor exporters of grapefruit who rely on individual exporters. Although Cyprus grapefruit is marketed by many independent exporters, the Cyprus Ministry of Commerce and Industry fulfils some of the functions of a central marketing organisation, such as quality control prior to export, and advertising and promotion in the importing countries.

The two largest central exporting agencies are the Citrus Marketing Board of Israel (CMBI) and the South African Citrus Board, usually known in importing countries as the Outspan Organisation. These organisations are government agencies and the sole exporters of fresh citrus fruit from Israel and South Africa respectively. The CMBI and the Outspan organisation cover every aspect of marketing from providing packing materials (bought in bulk), exercising a strict quality control on all fruit exported, and arranging for shipment to importing countries, to checking quality at the ports of discharge (a sample is taken of the fruit from each pack-house) and promoting sales of citrus under the brand names "Jaffa" and "Outspan" respectively. These organisations maintain offices in the major importing countries which inform the Head Offices of the day-to-day changes in prices and the supply positions in the various markets, so that supplies may be channelled to markets according to their requirements. If necessary the CMBI and the Outspan Organisation arrange for the fruit to be held in cold-storage, particularly towards the end of the season, in order to smooth out fluctuations in supply and extend their marketing seasons.

Since 1965, when the export of agricultural produce was nationalised, all Moroccan citrus has been exported by the Organisation for Commerce and Export (OCE), which operates on very similar lines to the CMBI and the Outspan Organisation. Although the individual co-operatively - owned pack-houses still use their own brand-names, Moroccan citrus is promoted under the general brand-name "Maroc".

Several of the exporting countries in the Caribbean have channelled all citrus exports through the citrus growers' co-operative associations since before the War. The Citrus Growers Associations (CGA's) of Jamaica, and Trinidad and the Surinam Citrus General operate central pack-houses for the grading and packing of fruit for export, and are responsible for shipping the fruit to European markets (though not necessarily for exporting fruit to neighbouring countries). In Dominica the CGA is responsible for marketing export fruit which is packed in the Government-owned pack-house. The Jamaican and Trinidad CGA's also organise small scale advertising campaigns in the importing countries (chiefly in the United Kingdom).

Where any form of central exporting agency exists it is usual for all export receipts to be pooled and the growers paid an average price, which may take into account the quality of their fruit, and the time of year when it was supplied. A standard charge would be deducted for packing, shipping and

importers' commission. In Dominica, however, each grower's fruit is separately selected for packing and the growers receive a payment based on the average wholesale price achieved by each consignment including their fruit, less the usual standard charges. It is understood that Morocco intended to change from a pool system to a system of individual grower payments in the 1969/70 season.

However the payment due to each grower is calculated, it is normal for the grower to receive the sum due to him in instalments - a fixed (and frequently nominal) sum per box of fruit delivered to the pack-house and one or more lump-sum payments at the end of the season, when the total payment due to each grower has been calculated. Jamaica is an exception to this rule; the growers there receive only one payment, when the fruit is delivered to the pack-house, this being based on the estimated average net return per box.

As regards marketing of grapefruit in the importing countries virtually all exporters, whether private or government concerns, adopt a similar pattern of trade. The fruit is consigned, or sold, to one or more agents - in the case of the larger Marketing Boards, their local offices; in the case of other exporters, importing firms - and distributed by the agents to a "panel" of wholesalers and brokers throughout the importing country. Wholesalers are appointed to the panel each season and their re-appointment frequently depends on their performance as regards quantities sold and prices obtained. There is considerable prestige (and a large volume of trade) involved in being appointed to the panels of the major Marketing Boards. The use of wholesale panels is very widespread in the United Kingdom, France, Switzerland and Scandinavia, but in the Netherlands and, to a decreasing extent, in Germany, large quantities of grapefruit are sold at the auctions. In this case the importer may sell the fruit himself or appoint brokers to the panel.

The influence exerted by exporters on their wholesale panels varies considerabl and depends on the competitive strength of the exporter. Both the Outspan Organisation and the CMBI have set target prices each week in recent seasons for the various grades and counts of their fruit in each market, and in practice the target prices frequently become the ruling market prices. The Outspan Organisation further limits the freedom of action of the wholesaler by prohibitin their panel members from handling competing citrus without the Organisation's permission. The CMBI attempted to enforce a similiar exclusive contract on its panel members a few years ago, but was unsuccessful, in the United Kingdo at least, presumably because of the greater number of supplying countries during the Israeli season. Minor Marketing Boards and individual exporters of course can exert little influence on their wholesale panels.

Although most Marketing Boards and importers sell direct to major outlets such as chain stores the basis of these contracts is not known. Some Boards base their selling price on the ruling wholesale price while others operate a fixed price over a season, or part of a season.

The export returns received by the different supplying countries, as shown in their Trade Returns, are generally influenced by the country's supplying season. Thus the highest returns are realised by suppliers during the summer months eg South Africa (and to some extent the United States), and particularly by those who can supply world markets during September and October, when grapefruit supplies are especially limited eg Jamaica. Conversely, suppliers during the Northern Hemisphere season - late October to April - receive lower returns, particularly if the bulk of their exports is sold during the months January to March (eg Trinidad).

Other factors also affect the export returns, for example distance from markets - this probably helps to explain the low Brazilian returns (Brazil being very far distant from her European markets). The quality of fruit exported from each country will also affect export returns - for example Israeli grapefruit is generally considered to be of very good quality and Israel records higher export values than Spain in spite of the latter's more favourable season (October to December only), and proximity to European markets, probably because Spanish grapefruit is not always of good quality.

Israel

The expansion in exports of grapefruit from Israel has paralleled the expansion of production in that country. From the 45,750 tons exported in 1959 exports of fresh grapefruit increased more than threefold to 152,411 tons in 1968 (see Table II of Appendix D). However exports during 1969 are likely to show a decline, since the 1968/9 crop finished early. Export availabilities in the 1969/70 season were estimated at approximately 155,000 tons. (30)

Israeli exports are consigned almost entirely to Western European countries, notably the German Federal Republic (hereafter referred to as Germany), the United Kingdom and France, who took respectively 27 per cent, 24 per cent and 22 per cent of Israel's grapefruit exports in 1968, followed by Belgium (7 per cent) the Netherlands (6 per cent), Switzerland (4 per cent) and Italy (3 per cent). Germany has been Israel's largest export market since 1965 - before that year the United Kingdom was the major outlet, taking 32 per cent of exports in 1964 compared with Germany's 20 per cent.

Israel's grapefruit production is aimed at the fresh grapefruit trade, and all grapefruit, whether sold ultimately for processing, on the domestic market or for export is handled by the Citrus Marketing Board (CMBI), which was established shortly after the Second World War. Growers send all their fruit to one of the Board's 52 packing-houses where it is sorted into two export grades, a domestic grade, and culls for processing.

Since there are no cold-storage facilities for citrus at the ports of Haifa and Ashdod, deliveries of fruit from packing-house to port are very carefully co-ordinated to coincide with the time of the ship's arrival. Citrus is never held in the port for more than two days before loading into refrigerated ships. At the port the fruit is inspected again by the Government inspectorate to ensure that it meets international quality standards.

Shipment from Israel to Europe takes between one and two weeks, according to the port to which the fruit is consigned. Citrus intended for Northern Europe may be shipped to Trieste or Marseilles and then on-shipped by rail, but more commonly is sea-freighted to a North European port which is not however decided until the ship nears Europe, according to the market situation

Israeli grapefruit is chiefly sold on a consignment/commission basis in the United Kingdom, Germany, the Netherlands and Belgium and on a firm price basis to Switzerland, Austria, Scandinavia, while 30 per cent of sales to France are also on a firm price basis. All Israeli grapefruit is sold under the "Jaffa" brand which is heavily promoted and advertised in the national and trade press and on television.

Since the 1967/8 season some grapefruit from Gaza has been handled by the CMBI but was sold under separate brand names. In the 1969/70 season it is expected that most Gaza grapefruit will be packed to the CMBI standards and sold by the Board under the "Azdar" brand name.

In order to extend the marketing season Israeli grapefruit is held for up to two months in cold stores in the various importing countries at the end of the harvesting season. This permits the marketing of fruit from October until May, or even June, although harvesting is completed by April.

Since 1964 average export returns have shown an upward trend, from £42 19s 0d per ton in 1964 to £48 3s 0d per ton in 1968 (it should be remembered that Israel devalued in late 1967).

The United States

Immediately after the Second World War the USA was a major supplier of grapefruit to European markets, however her exports to this area have suffered in comparison with the newer suppliers, in the sense that US exports have risen at a slower rate than European consumption, for several reasons. After the War there was a dollar shortage and quotas and various other restrictions were placed on the importation of American fruit into most European countries, indeed, the United Kingdom still maintains a quota for imports of grapefruit from the Dollar Area. Even when restrictions on imports were lifted it proved difficult for Florida grapefruit in particular to compete with Israeli on European markets because high labour costs and shipping

costs made the American fruit more expensive than Israeli and also, although Florida grapefruit is of good eating quality, it does not have the attractive outward appearance of Mediterranean-grown desert-type grapefruit and has a relatively short shelf-life. Californian grapefruit, although also expensive in comparison with the Israeli, does not suffer as regards quality, and also grapefruit from some areas of California is available during the summer months and does not compete with Israeli fruit.

Nevertheless until 1962 total US exports of fresh grapefruit showed an upward trend and exceeded 100,000 tons in that year (much of this total going to Canada) but the frost of the following season reduced the quantities of fruit available for export, and exports fell to just over 70,000 tons. However exports increased again to reach 115,000 tons in 1967 before the poor crop of 1967/8 again reduced the quantity of fruit available for export, only 78,660 tons being exported in that year (see Table III of Appendix D). However since production is expected to increase substantially in the future, it seems likely that efforts will be made to increase exports.

The largest single market for US grapefruit is Canada, who usually takes about seventy per cent of US exports and actually took more than 80 per cent in 1968. Other major markets are France, who accounted for 9 per cent in 1967 (a more typical year than 1968), the Netherlands (7 per cent) and West Germany (3 per cent). Of these latter three countries only France has taken increasing quantities of grapefruit over the last decade. Exports to the Netherlands, Germany and other countries in Europe have remained static or even fallen in recent years, although it is possible that some grapefruit consigned to France is re-exported to other European countries.

Exporting is carried out by the large citrus marketing organisations which are generally organised on a co-operative basis and sell their members' fruit under several brand names. Examples are the Florida Citrus Mutual which has more than 14,500 members, the Seald-Sweet Organisation which has more than 3,000 members and Sun-Kist Growers Inc. of California. Some of these organisations sell grapefruit on an fob or c and f basis, which is unpopular with many European importers, while others sell on a consignment/commission basis. There is no standardisation of packaging as between marketing organisations and of course many brand names are sold on export markets. However, each State imposes standards of quality and maturity.

Average export returns were only £38 7s 0d per ton for the years 1960 to 1962, rose to £54 18s 0d in 1964 and then declined to £44 5s 0d in 1967 before rising again to £64 8s 0d in 1968 following the short 1967/8 crop.

Republic of South Africa

South Africa has the advantage of being the only major supplier of grapefruit to world markets during the period May to September. Exports from the other major producer in the Southern hemisphere, Argentina, are negligible, and only Brazilian and Californian together with cold-stored Israeli fruit offer any competition. Exports rose from only 10,820 tons on average over the period 1957 to 1959 to 46,743 tons in 1967, chiefly as the result of rapidly increasing demand in France and West Germany (see Table IV of Appendix D). Exports to South Africa's traditional market, the United Kingdom, have also risen and still accounted for 51 per cent of the total in 1967, when Germany and France took 23 and 16 per cent respectively. Exports to other countries of Western Europe have remained small, although over 1,000 tons, or 2 per cent of the total, was consigned to Italy in 1967. Preliminary figures for 1968 show another considerable increase in total exports to 56,800 tons.

All large-scale citrus growers in South Africa belong to the co-operative Citrus Exchange, whose representatives have a majority on the South African Citrus Board which controls the marketing of the fruit. The Citrus Board also markets the fruit of growers in Swaziland and Southern Mozambique who are affiliated to the Citrus Exchange.

The Board's overseas sales organisation, known as the Outspan Organisation (all South African citrus is sold under the Outspan brand, as is also that from Swaziland and Mozambique handled by the Citrus Board), is centred on London and has national Sales Offices in other major importing countries.

The Citrus Board deals directly with large buyers such as multiple stores and may even pack citrus in boxes of their customer's specification. However this makes for inefficiency in packing and shipping and the Board may discontinue this service in future. Sales to large-scale buyers are usually on a fixed-price basis, contracts being made for the season.

Over the last six seasons average export returns have been high compared with those of most other suppliers ranging from £40 2s 0d per ton in 1966 to £56 9s 0d in 1963; preliminary figures put average returns for 1968 at £52 10s per ton.

Cyprus

Cyprus has benefitted from preferential treatment on the British market (where her non-Commonwealth competitors pay a 5s 0d per cwt import duty) but even so, exports to the United Kingdom accounted for only 53 per cent of the total in 1968 as compared with 78 per cent in 1962 (see Table V of Appendix D). Expansion of exports to Germany has been particularly rapid, rising from only 800 tons (8 per cent of the total) in 1962 to 9,460, or 29 per cent in 1967, although there was a decline in exports to this country in 1968

Other important export markets are the Netherlands, which took 7 per cent of the total in 1968, and Switzerland (4 per cent). Various East European countries, notably Czechoslovakia and East Germany, have on occasion taken significant quantities of Cyprus grapefruit.

A very large proportion of the Cyprus grapefruit crop is exported as fresh fruit (approximately 80 per cent) - alternative outlets, the domestic market and processing, are extremely limited. There is no central export organisation in Cyprus - private exporters, large growers and co-operatives export on their own account under many different brand names. The Ministry of Commerce and Industry, however, undertakes many of the functions of an exporting organisation. The Ministry issues free point-of-sale advertising material to retailers and organises promotions for Cyprus citrus through the commercial sections of the Cyprus embassies in importing countries. It is intended to set up a Citrus Organisation to regulate production and exports, improve standards, and extend advertising in export markets, although the actual exporting would continue to be carried out by individuals. However when first put to the citrus industry the scheme was turned down. Average export returns for grapefruit have shown a rising trend from approximately £32 per ton in 1962 to £45 8s 0d per ton in 1968.

Trinidad

Exports of fresh grapefruit from Trinidad have fluctuated widely during the last decade - in 1962 at 10,100 tons Trinidad's exports exceeded those of Cyprus, but since then exports have shown a declining trend and amounted to only 2,374 tons in 1968. In fact the major proportion of grapefruit grown in Trinidad is now processed into canned segments and juice - the canning of segments recommenced after the War only in 1962, which may partly explain the fall in exports of fresh fruit since that year.

The United Kingdom has always been the major market for Trinidad grapefruit, usually accounting for between 65 and 85 per cent of exports. However in 1967 the UK took only 56 per cent of Trinidad's grapefruit exports while Germany accounted for 43 per cent. Germany is the only large export market for Trinidad grapefruit apart from the UK, but consignments to that country have been rather erratic, ranging from 1,900 tons in 1967 to only 550 tons the following year.

The co-operative Citrus Growers Association has handled all citrus exports since 1932. Grapefruit is stamped with the brand name "Trinidad" and has been promoted together with Trinidad canned grapefruit segments and juices.

Export returns for Trinidad grapefruit fell from £34 13s 0d per ton on average over the years 1957 to 1959 to £31 13s 0d per ton in 1965, but rose again to £35 16s 0d per ton in 1968. (Trinidad also devalued in late 1967) Trinidad's grapefruit suffers stiff competition from Israeli and Cyprus fruit, since her export season begins in January.

Morocco

Grapefruit is a minor crop in Morocco and exports have shown a decline in recent years. From an average of 7,160 tons exported during the years 1960 to 1962 exports fell to 3,320 tons in 1965, then rose again during the next two years before falling to 2,870 tons in the 1967/8 season and to 980 tons in 1968/9 (31). France has traditionally been Morocco's main export market and took 92 per cent of her exports of grapefruit in the years 1957 to 1959. From 1960 Germany became an increasingly important market and in 1964 and 1965 was the largest importer of Moroccan grapefruit, taking 47 per cent and 49 per cent respectively of her exports in thos two years, as against the French 26 per cent and 35 per cent. However exports to Germany fell to 18 per cent in 1967 and were negligible in the 1967/8 and 1968/9 seasons. (31) The United Kingdom has also become an important market latterly - she took 23 per cent of Morocco's grapefruit exports in 1967.

The marketing of Moroccan citrus, and other vegetable products, was nationalised in 1965 under the OCE (Office for Commerce and Export). The packing-houses work on a group basis covering particular areas, although they are privately or cooperatively owned.

The OCE has subsidiary companies (OCA) in the importing countries who check the quality of the fruit again and distribute it to a panel of wholesalers. Since nationalisation, Moroccan citrus has been promoted under the "Maroc" brand name, which has been stamped on the fruit this season (1969/70), although the cartons still show individual packing-house brand-names.

Average export returns for Moroccan grapefruit fluctuated between £32 17s 0d and £44 7s 0d per ton over the years 1963 to 1967.

Spain

Again grapefruit is a very minor crop in comparison with oranges, but exports of grapefruit rose from an average of 1,046 tons over the years 1957 to 1959, to 3,959 tons in 1966, before falling again to 3,216 tons in 1968. Germany has been the largest market for Spanish grapefruit in most recent years, although in 1966 the United Kingdom, usually the second largest market, took first place Other important buyers of Spanish grapefruit are France, the Netherlands, Switzerland and Belgium. In 1967 the relative proportions taken by these countries were Germany - 39 per cent, United Kingdom - 25 per cent,

France - 15 per cent, Switzerland - 9 per cent, the Netherlands - 8 per cent and Belgium - 3 per cent.

Spanish citrus is handled by a multitude of private exporters, some of which are also growers. Generally speaking exporters buy from the growers at a firm price when the fruit is still on the trees or delivered to the pack-house and thus the exporters carry all the risks of exporting. The exporters pack the citrus and arrange for shipping (frequently by rail, rather than by sea). Sales are made on a consignment/commission basis in countries where auctions still operate and on a firm basis to those countries (chiefly Scandinavia) where no auctions are held. Average export returns for grapefruit fell from £33 8s 0d per ton on average from 1960 to 1962 to only £23 4s 0d per ton in 1965 before recovering again to £32 0s 0d per ton in 1968. (Spain also devalued in late 1967).

Jamaica

Jamaican exports of fresh grapefruit are of minor importance in relation to the quantities used for processing and the volume of fresh fruit exports has fluctuated considerably in recent years, reaching a high of 6,056 tons in 1963 and a low of 1,604 tons in 1966. A very large proportion of Jamaican grapefruit is exported to the United Kingdom, between 65 per cent (in 1965) and 100 per cent (in 1967). Substantial quantities have also been consigned to New Zealand under a fixed price agreement, while smaller quantities have been sent to Germany and the Netherlands. In the United Kingdom, Jamaican citrus is promoted under the Juciful brand name.

As in Trinidad, all exports of grapefruit are channelled through the Citrus Growers' Association which packs the fruit and consigns it to importers. After rather low average exports returns during the period 1960 to 1962 (£34 9s 0d), export returns exceeded £61 0s 0d per ton from 1963 onwards, reaching £77 18s 0d in 1967 before falling to £65 0s 0d in 1968. These unusually high returns probably result from Jamaica's favourable export season, during September, October and November, when grapefruit prices are at their highest. The system of payment to growers is unusual in that there is only one payment based on the estimated average return per box. (32)

Surinam

Exports of grapefruit from Surinam also tend to fluctuate from year to year - in 1963 approximately 3,500 tons were exported, but in 1964 less than 1,800 tons. The Netherlands is usually the only major export market for Surinam grapefruit, but in 1960 over 1,700 tons were consigned to the United Kingdom.

Most grapefruit for export is packed in the Central Packing-house operated by a semi-governmental body composed of citrus growers, known as the Surinam Citrus General. It is understood that the bulk of Surinam grapefruit

has been consigned or sold direct to a large supermarket chain in the Netherlands(33) during recent seasons. Export returns averaged around £25 0s 0d per ton over the period 1963 to 1966.

Brazil

Although Brazil is only a minor exporter she supplies world markets during the Northern hemisphere summer months when supplies are generally limited. However Brazilian exports fell from a peack of 3,900 tons in 1963 to 1,700 tons in 1966 although they subsequently recovered to 2,100 tons in 1967. Before 1965 the United Kingdom was the major export market for Brazilian grapefruit, taking over 60 per cent on average from 1960 to 1963, but exports to the UK fell to only 227 tons or 11 per cent cent in 1967. During the 1966 and 1967 seasons the Netherlands was the major outlet, taking 49 per cent in 1967, while West Germany and Sweden accounted for 32 per cent and 8 per cent respectively in the latter year.

The export of citrus is not centrally organized in Brazil, and individual exporters prefer to sell on fob terms since the cost of shipping to European markets is very high and consignment/commission sales are therefore very risky. The high cost of transport probably explains the low fob prices realized for grapefruit exports, which fell from £22 9s 0d per ton on average from 1957 to 1959 to only £12 19s 0d per ton in 1966, although returns improved to £16 6s 0d per ton in 1967.

Dominica

Dominica is a minor producer of grapefruit, but exports have risen from only 692 tons in 1960 to 2,486 tons in 1967. A major proportion of these exports is consigned to the United Kingdom (84 per cent in 1960 and 94 per cent in 1967), the remainder being exported to other islands in the Caribbean. Although Dominica exports relatively small quantities of grapefruit, exports to Europe are concentrated into the three months of the year - September to November - when world supplies of grapefruit are limited and Dominican grapefruit is an important factor on the United Kingdom market during these months.

The Co-operative Citrus Growers' Association of Dominica is dominated by the larger citrus growers; members are required to market all citrus fruit for export or processing through the Association. Each grower has his fruit separately selected for packing and is not therefore penalized by the presentation of sub-standard fruit by other producers. (34) The CGA organizes the shipment of grapefruit to Europe on the banana boats owned by Geest Industries Ltd, who are also UK importers and wholesalers.

Average fob returns for grapefruit exported to the United Kingdom fell from an average of £42 5s 0d per ton during the period 1960-62 to only £20 7s 0d per ton in 1966 before rising again to £32 0s 0d per ton in 1968.

Imports

The tonnage of fresh grapefruit imported by the major markets (chiefly Canada and the countries of Western Europe) in 1967 was twice the 1957 to 1959 average (see Table 2 on page 26). All importing countries, other then the United States and New Zealand, showed some increase in imports over this period, ranging from 34 per cent in the case of Norway to Italy's 3,076 per cent increase (the latter from a very low base).

Before the Second World War the United Kingdom and Canada were the only large importers of grapefruit, the United Kingdom alone accounting for between 50 and 60 per cent of world imports. (35) After the War, however, UK imports dropped to half their pre-War level whereas Canadian imports had doubled. Although imports into many Continental European countries began to increase during the nineteen-fifties, imports into the UK were slow to recover and Canada was the major importer of grapefruit until 1960. After 1959 imports into the United Kingdom began to increase, while Germany, France and the Netherlands, in particular, became of increasing importance as importers. Canadian imports almost entirely from the United States, fluctuate according to the size of the US crop and therefore were low in 1963 and 1964 and unusually high in 1967.

Some minor importing countries such as Belgium, Switzerland and the Scandinavian countries, showed a less rapid rise in imports than France, Germany and the Netherlands, but Italian imports rose very rapidly from less than 200 tons in the period 1957 to 1959 to 6,500 tons in 1968.

Of the non-European importers Japan has increased her imports of grapefruit, although these are subject to quota limitation, and compete with the locally-grown summer oranges (Natsu-daidai). United States imports, always marginal, showed a downward trend to 1964, after which year grapefruit imports were not separately shown in the Trade Returns. New Zealand is virtually self-sufficient in local grapefruit-like hybrids but imports about 300 tons of grapefruit from Jamaica every year. Imports of grapefruit into the Comecon countries are small and sporadic, depending on bilaterial trade agreements, and amounted to about 5,000 tons in 1967.

Imports into the major importing countries are discussed below. The general decline in imports from the USA in 1968 is partly explained by the short US crop of 1967/8.

The United Kingdom

During recent years the United Kingdom has been the largest world importer of grapefruit, with the exception of 1967, when Canadian imports were unusually high. Imports in 1968 amounted to 91,175 tons - twice the average tonnage for the years 1957/59. However the upward trend has not been a steady one (see Table VI of Appendix D).

Table 2

Imports of Grapefruit into Various Countries

	1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	19
United Kingdom	45,590	60,441	56,822	72,462	71,075	75,382	79,801	91
Canada	59,738	66,818	49,733	54,254	66,735	63,283	80,921	68
German Federal Republic	19,051	25,275	34,271	40,810	49,385	59,743	61,792	73
France	17,250	21,760	26,577	33,002	36,849	40,466	46,378	53
Netherlands	4,733	7,687	9,704	11,099	12,120	11,862	15,412	20,
Belgium	6,215	5,980	6,580	8,593	9,381	9,686	11,111	11,
Switzerland	...	6,603	7,042	8,279	7,464	7,681	9,856	9,
Italy	154	269	313	686	1,558	3,361	4,891	6,
Sweden	2,423	2,597	3,241	4,070	4,745	4,474	4,530	4,
Denmark	1,790	2,424	2,618	3,523	3,228	3,615	3,597	3,
Finland	944	1,178	1,575	2,003	2,043	2,164	2,160	2,
Norway	1,029	1,068	1,025	1,120	1,527	1,570	1,380	1,
Japan	...	...	426	730	659	1,020	1,108	1,
United States	1,557	919	387	899	...	...	...	..
New Zealand	313	312	328	314	304	275	299	..
TOTALS (a)	160,787	203,331	200,642	241,844	267,073	284,582	323,236	346,

... Information not available

(a) Totals of available figures

Source: Trade Returns

Throughout the period under review (1957 to 1968) the major suppliers of the United Kingdom market have been Israel, South Africa and Cyprus, in that order, although during the period 1957 to 1962 the Caribbean countries as a group (Jamaica, Trinidad and the Windward Islands) were of more importance than Cyprus. Over the whole period Israel and Cyprus increased their shares of the British market - from 35 per cent and 12 per cent respectively in 1957/59 to 45 per cent and 18.5 per cent in 1968. South Africa had 21 per cent of the market in 1957/59 and 1968, but the share of the Caribbean countries fell from 14 per cent to 5 per cent. This decline was due to smaller consignments from Trinidad and Jamaica - receipts from the Windward Islands (almost entirely Dominica) increased by 150 per cent between 1960 - 1962 and 1968.

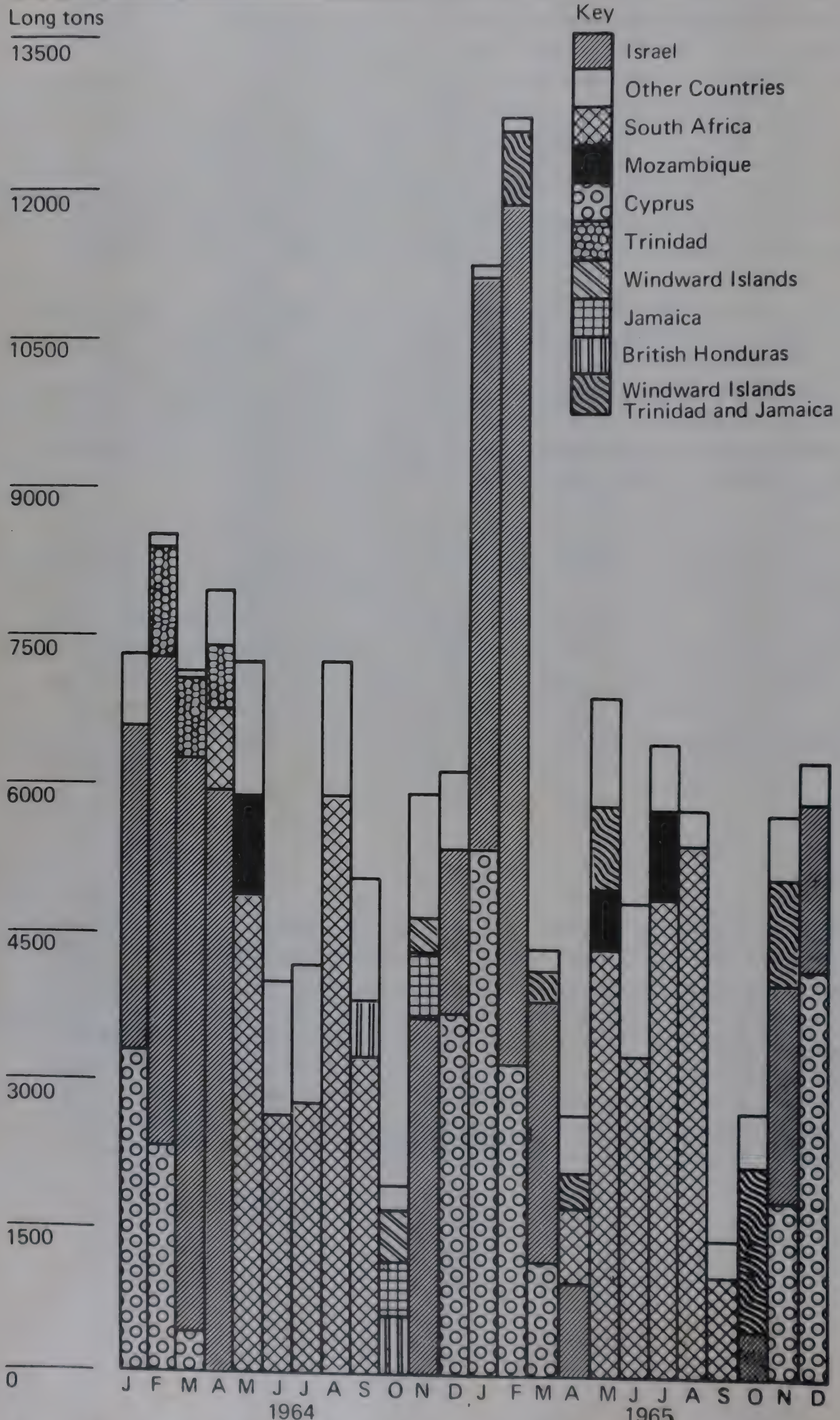
Minor suppliers to the United Kingdom market include Swaziland, who in 1968 supplied 5,082 tons, accounting for nearly 6 per cent of UK imports, compared with less than 300 tons on average between 1960 and 1962. Imports from Mozambique also rose, from 1,045 tons in 1957 to 1959 to 3,894 tons in 1967, although there was a decline to 1,857 tons in 1968. The United States, Spain and Morocco send small quantities of grapefruit to this market but imports from Argentina, Brazil and British Honduras have declined.

The seasonal distribution of imports generally shows a high level of imports during the months December to May, with a peak in February or March, and a lower level of imports during the summer, reaching a trough in September or October (see fig. 3). The histograms of monthly imports during the years 1964 to 1969 show that Israel is the main supplier of grapefruit from November or December until April, while South Africa supplies the market from April to September. The season for Cyprus grapefruit extends from October or November until February or March. Spain and Morocco supply the market from October until December and Trinidad from January or February until April or May.

Suppliers during the summer months include, besides South Africa, Swaziland, Mozambique, Brazil and the United States. Jamaica, the Windward Islands (Dominica) and in earlier years, British Honduras, have the advantage of supplying the market during September, October and November when competition from the major suppliers is least severe. Imports from the United States, a potential supplier during these months, are permitted only during the months December to September (before 1968/9 only from March to September). In 1968, a substantial quantity of Lebanese grapefruit was received in October, and in 1969 several shipments were received from Cuba during this month.

Figure 3a

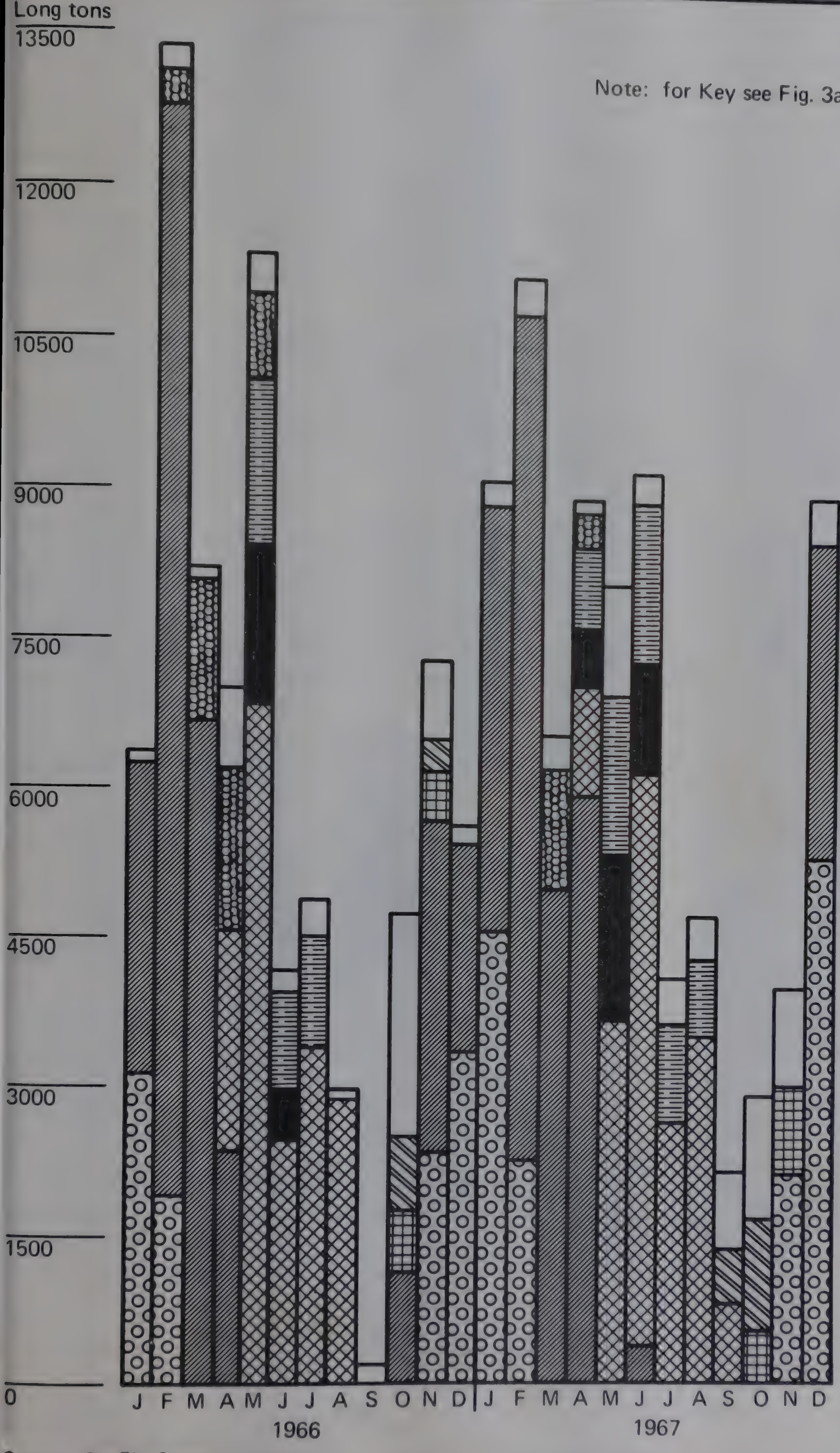
Grapefruit Monthly imports into the U.Kingdom 1964-65



Source: Fruit Intelligence, Commonwealth Secretariat.

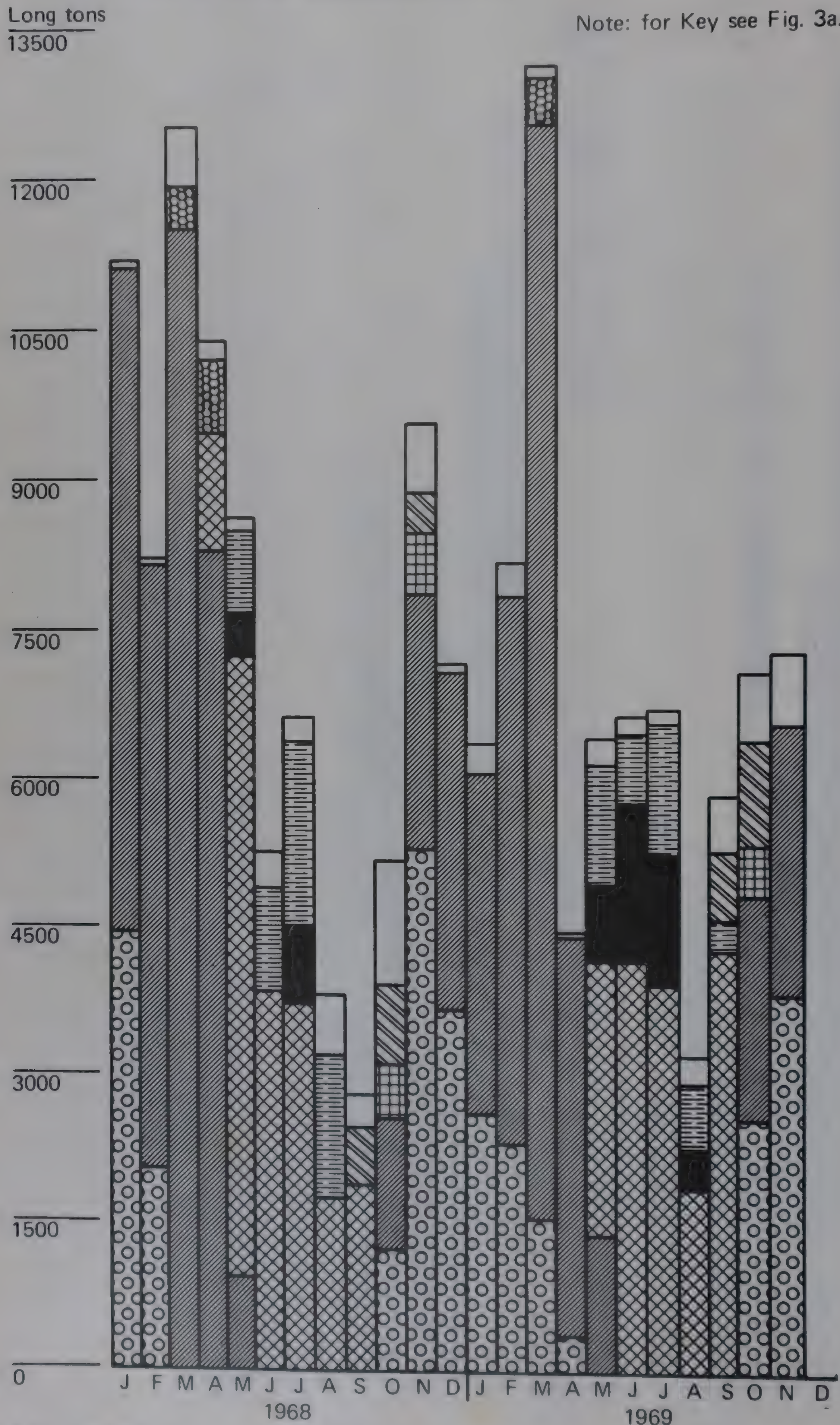
Figure 3b

Grapefruit Monthly imports into the U.Kingdom 1966-67



Source: See Fig. 3a.

Figure 3c
Grapefruit Monthly imports into the U.Kingdom 1968-69



Source: See Fig. 3a.

Canada

Canadian imports of grapefruit have shown an upward trend with considerable year to year fluctuations over the period 1957-59 to 1968 (see Table VII of Appendix D). The great dependance of Canadian imports on American supplies is demonstrated by the fact that in most years the United States supplies 99 per cent of Canadian imports - the only exceptions being 1964 and 1968 when the American crop was smaller than usual and the US supplied only 97 per cent of Canadian imports. British Honduras supplied the Canadian market until 1963, while South Africa has consigned increasing quantities of grapefruit to Canada since 1964, and accounted for nearly 2 per cent of total imports in 1968. Other suppliers include Mexico, Cuba, Jamaica, Brazil and even Hong Kong.

The seasonal distribution histograms (fig. 4) show a definite seasonal pattern of imports. Supplies are at their peak during the first four or five months of the year, then there is a sudden fall in May or June followed by a decline in imports to their lowest point in September or October. In October or November the United States' new season's crop becomes available and imports immediately return to a high level.

The United States is, as would be expected, the major supplier of grapefruit in every month of the year. South Africa supplies the market from June to September or October (as in 1966) and Cuba from October to December. Small quantities are received from Hong Kong in the months October to February, and from Jamaica chiefly during the winter and early spring months, February to May. Mexico sends sporadic shipments, which were quite heavy in October and November 1968.

German Federal Republic

German imports of fresh grapefruit amounted to less than 2,000 tons before the War and it was not until 1955 that imports began to increase, as trade restrictions were lifted. In the period 1957 to 1959 grapefruit imports averaged 19,050 tons and by 1968 imports had reached 73,230 tons - a 284 per cent increase over the 1957/59 level (see Table VIII of Appendix D). However the rate of increase has slackened somewhat since 1966.

The pattern of supply has changed considerably over the last decade. In the years 1957 to 1959 the United States was the major supplier to this market, accounting for 43 per cent of the total, followed by Israel with 36 per cent and Spain with 7 per cent. However in 1967 Israel supplied 50 per cent of the total, South Africa (whose exports to Germany were negligible in 1957/59) 18 per cent, Cyprus (also a very minor supplier in 1957/59) 12 per cent, while the United States accounted for only 6 per cent. Supplies from the United States fell in absolute terms over the period under review and in 1968 (following Israel's devaluation) amounted to less than 750 tons. In 1968 Israel supplied 64 per cent of German imports.

Figure 4a

Grapefruit Monthly imports into Canada 1966-68

Source: Trade of Canada, Dominion Bureau of Statistics

Note: Columns show total imports, largely from the United States. Figures show totals from other countries (see Fig. 4b).

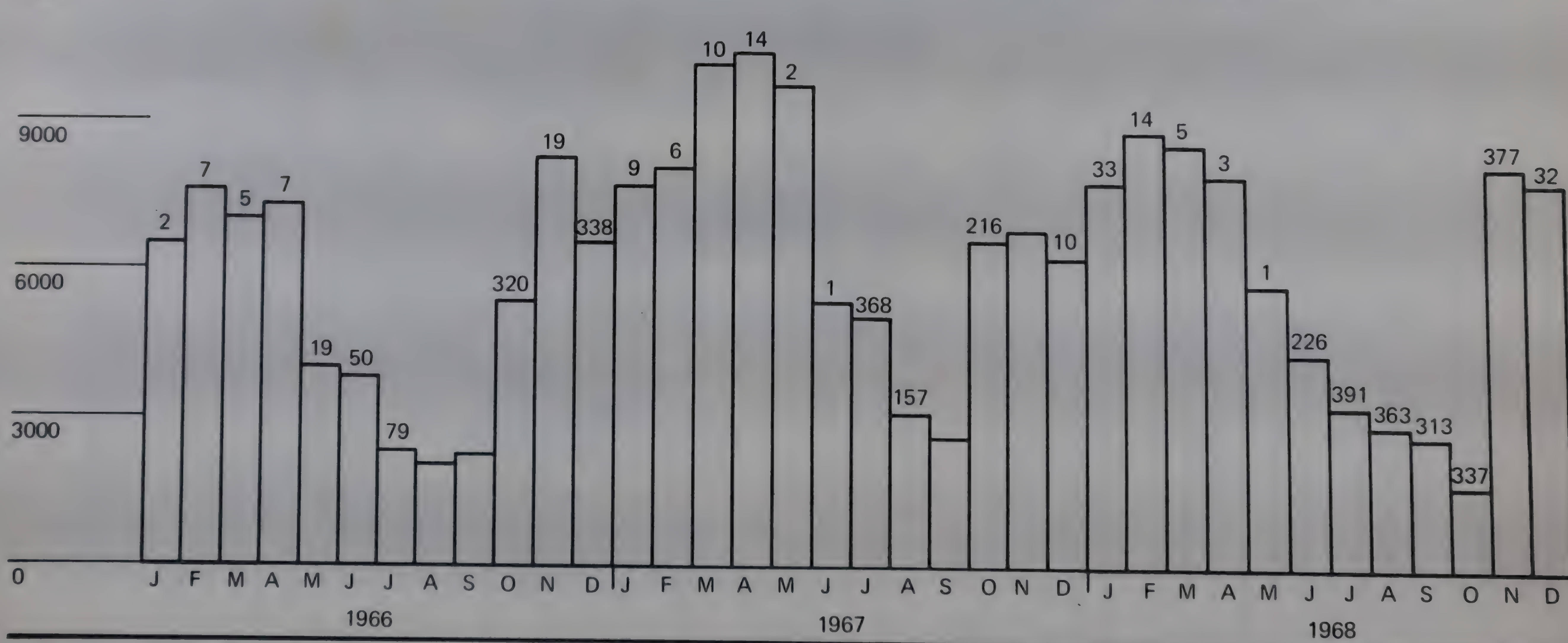
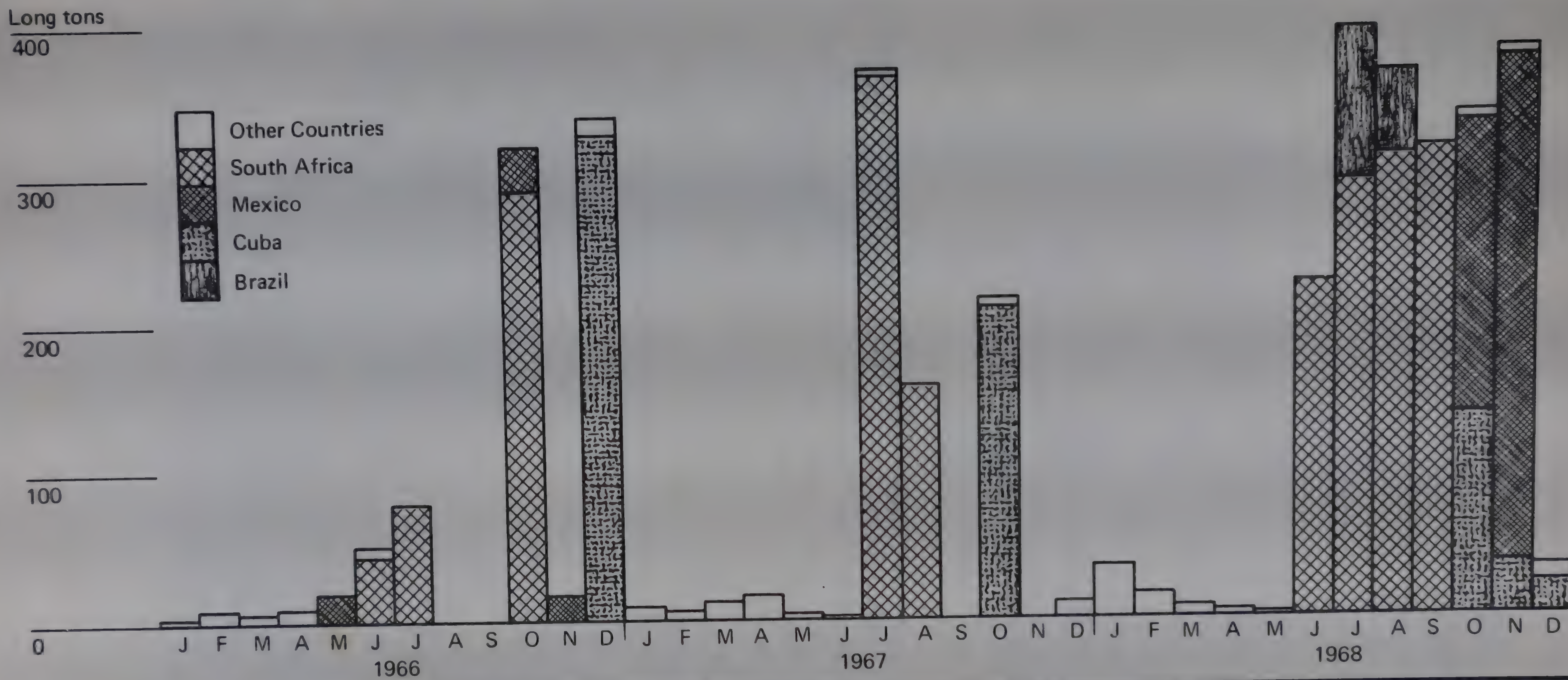


Figure 4b
Grapefruit Monthly imports into Canada from countries other than the U.S.A. 1966-68

Source: See Figure 4a



Minor suppliers to the German market include Spain, Turkey, Algeria and Morocco among Mediterranean producers, Brazil and Paraguay and also many of the Caribbean countries - the Honduras Republic, Jamaica, Trinidad, Surinam, and in 1967 and 1968, Cuba. Generally speaking the minor supplying countries are not increasing their exports to Germany and therefore have a declining share of the market.

The seasonal distribution histograms (Fig. 5) again show a peak during the spring months February to May and a lower level of imports from June or July until December. Imports are at their lowest in September. Israel now supplies this market from October or November until June or July - in 1968 August and September were the only 2 months that Israel did not dominate the German market. Cyprus grapefruit is received from November until April and Spanish chiefly in October and November, although small quantities continue to be received until April. South Africa is an important supplier from May to October and usually dominates the market from July to September. Small quantities of grapefruit are received from the United States and the Honduras Republic throughout the year.

France

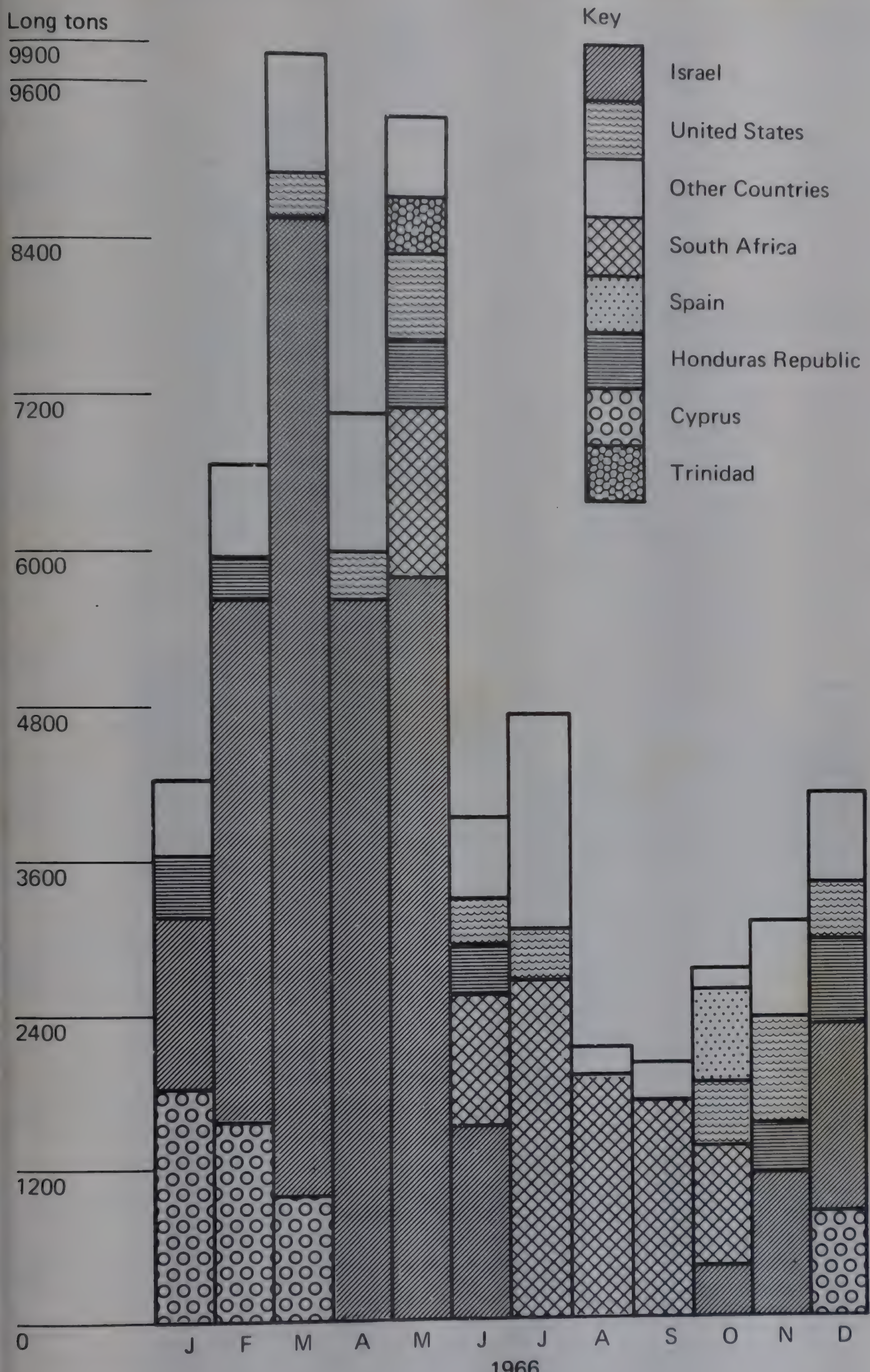
French imports of fresh grapefruit have also risen strongly during the period under review from an average of 17,250 tons in 1957/59 to 53,125 tons in 1968 - a 208 per cent increase (see Table IX of Appendix D). At the beginning of this period Israel, Morocco and Algeria supplied 41 per cent, 30 per cent and 16 per cent respectively of French grapefruit imports. However by 1967 the main suppliers were Israel (50 per cent), the United States (21 per cent) and South Africa (14 per cent), while Morocco and Algeria accounted for 5 per cent and 3 per cent respectively. In 1968 the market shares changed considerably - Israel alone supplied the 15 per cent increase in imports, while receipts from the United States and South Africa fell (possibly affected by the disturbances of May 1968 in France). The market shares in 1968 were Israel 69 per cent, the United States and South Africa both 9 per cent. Imports from Morocco and Algeria were also much lower, but Egyptian (Gaza) grapefruit accounted for 2 per cent of the total.

France is probably the only European market where the United States increased her market share over the period 1957 to 1967. It should also be noted that Cyprus and Spain are of little importance, in spite of their relative proximity to France. Minor suppliers to the French market included in 1968 the Honduras Republic, Surinam, Trinidad and even Sierra Leone and Australia.

Unfortunately seasonal import data is available only on a quarterly basis prior to 1968 and this tends to obscure the seasonal pattern of imports. In addition the seasonal distribution of imports in 1968 was almost certainly affected by the strikes in May and June of that year. However the histograms

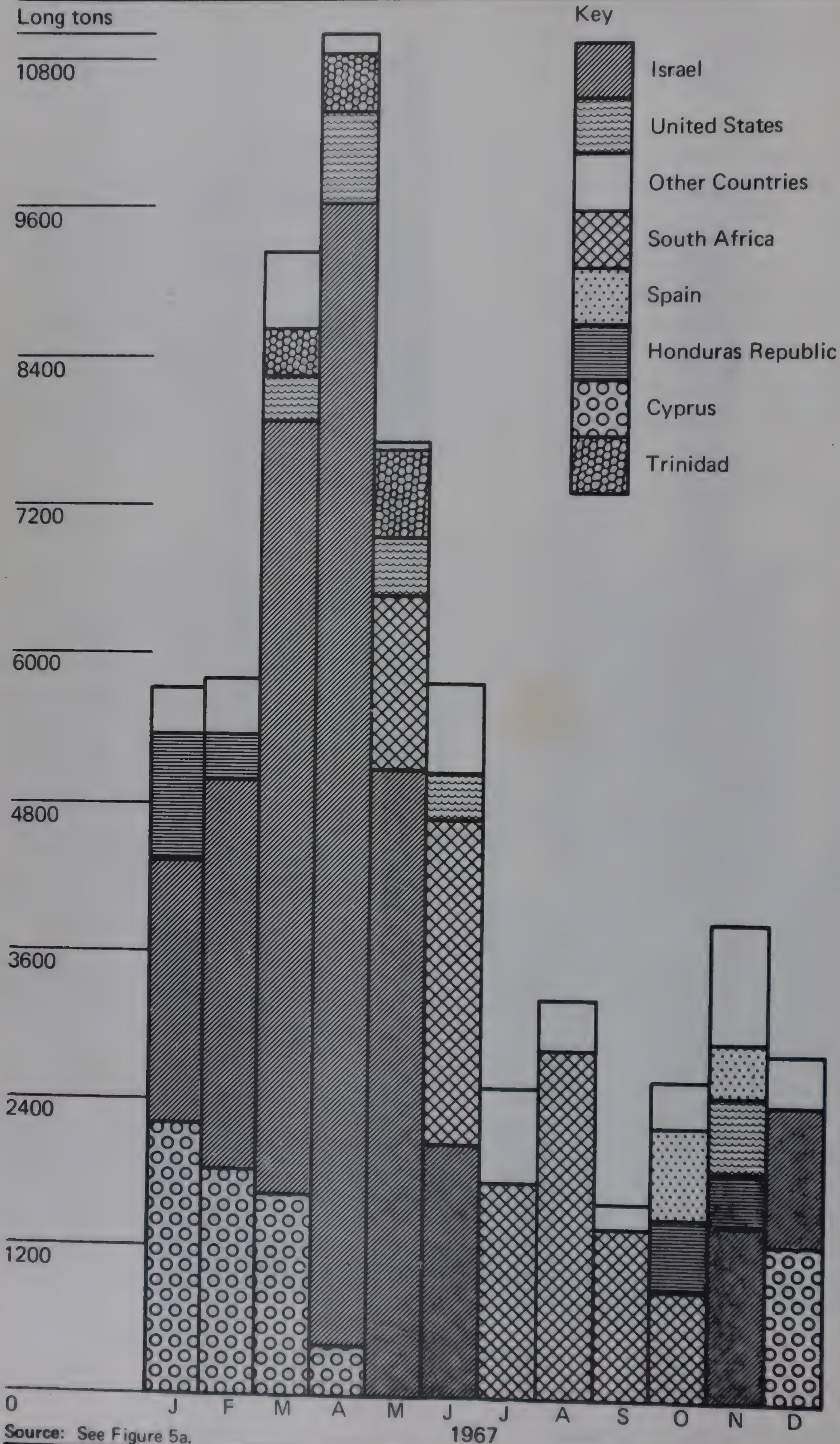
Figure 5a

Grapefruit Monthly imports into German Federal Republic 1966



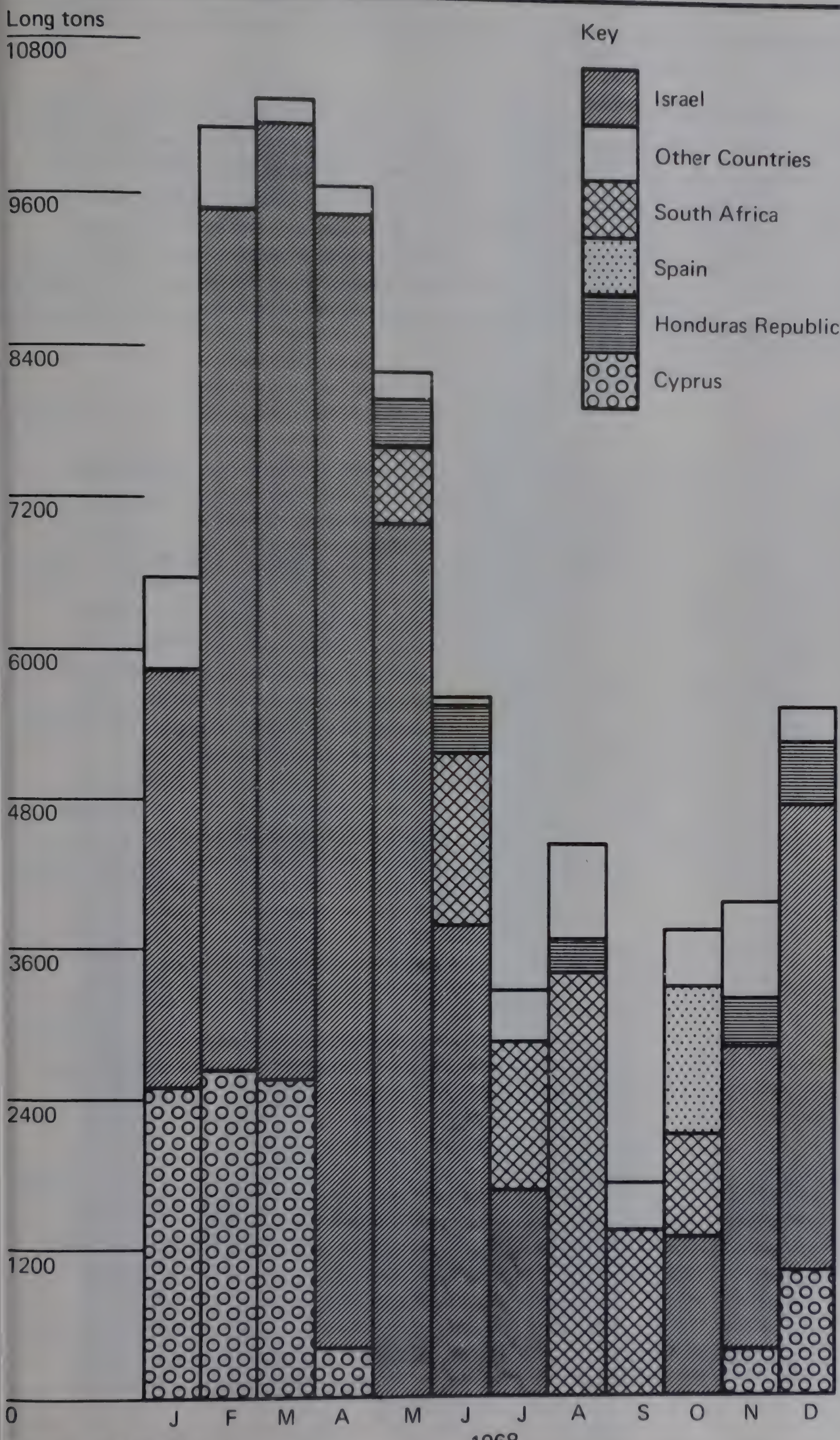
Source: Du Aussenhandel, Statistisches Bundesamt

Figure 5b
Grapefruit Monthly imports into German Federal Republic 1967



Source: See Figure 5a.

Figure 5c
Grapefruit Monthly imports into German Federal Republic 1968



Source: See Figure 5a.

(fig. 6) show that imports are highest during the period January to June - probably reaching a peak in March and April. Imports are at their lowest during the months July to September. It should be noted that for 1966 and 1967, the histograms show average monthly imports for each quarter and not quarterly totals.

Israel dominates the French market during the first quarter, and frequently, also during the second. Other suppliers during the first quarter include most of the Mediterranean producers, together with the United States and Surinam who both supply the French market throughout the year. Imports from South Africa and in 1966, Mozambique, are important during the second quarter and continue into the third, when Cuba and Honduras have also contributed supplies. The final quarter marks the beginning of the new Northern hemisphe season, dominated by Israel, although imports are received from most supplyi countries during this period.

The Netherlands

After a relatively slow increase in grapefruit imports during the immediate post-War period, demand increased rapidly over the period under review, from 4,733 tons on average during 1957/59 to 20,720 tons in 1968 - a rise of 338 per cent (see Table X of Appendix D). At the beginning of the period the Netherlands, like Germany and Belgium, imported a high proportion (43 per cent) of her grapefruit requirements from the United States, the other important suppliers at that time being Israel (26 per cent) and Surinam - a former dependency (23 per cent). However imports from the United States rose very little, while Israel's share of the market increased dramatically, particularly in 1968, after her devaluation. In 1968 the major suppliers to the Dutch market were Israel (54 per cent), Surinam (13 per cent), the United States (12 per cent) and the Honduras Republic (6 per cent). Minor suppliers included Cyprus, Brazil, Spain, Paraguay and Cuba. It should be noted that significant quantities of grapefruit are on-shipped from Belgium to the Netherlands, and that in some years re-exports from the Netherlands are quite substantial.

The seasonal distribution histograms of imports during 1966, 1967 and 1968 (Fig. 7) show the usual high level of imports during the winter and spring months and a low level from July to October, imports usually being at their lowest in August. However imports during the July to October period rose over the period 1966 to 1968 and in the latter year in particular the difference between winter and summer levels of imports was less pronounced than in other importing countries.

As in most other European countries, Israel is the major supplier of grapefrui from October or November until June or July. Spain and Cyprus supply the market from October until December, and the United States from April until December. Honduras is of importance chiefly from May to July and from

Figure 6

Grapefruit Monthly imports into France 1966-68 (quarterly data only available 1966 and 1967)

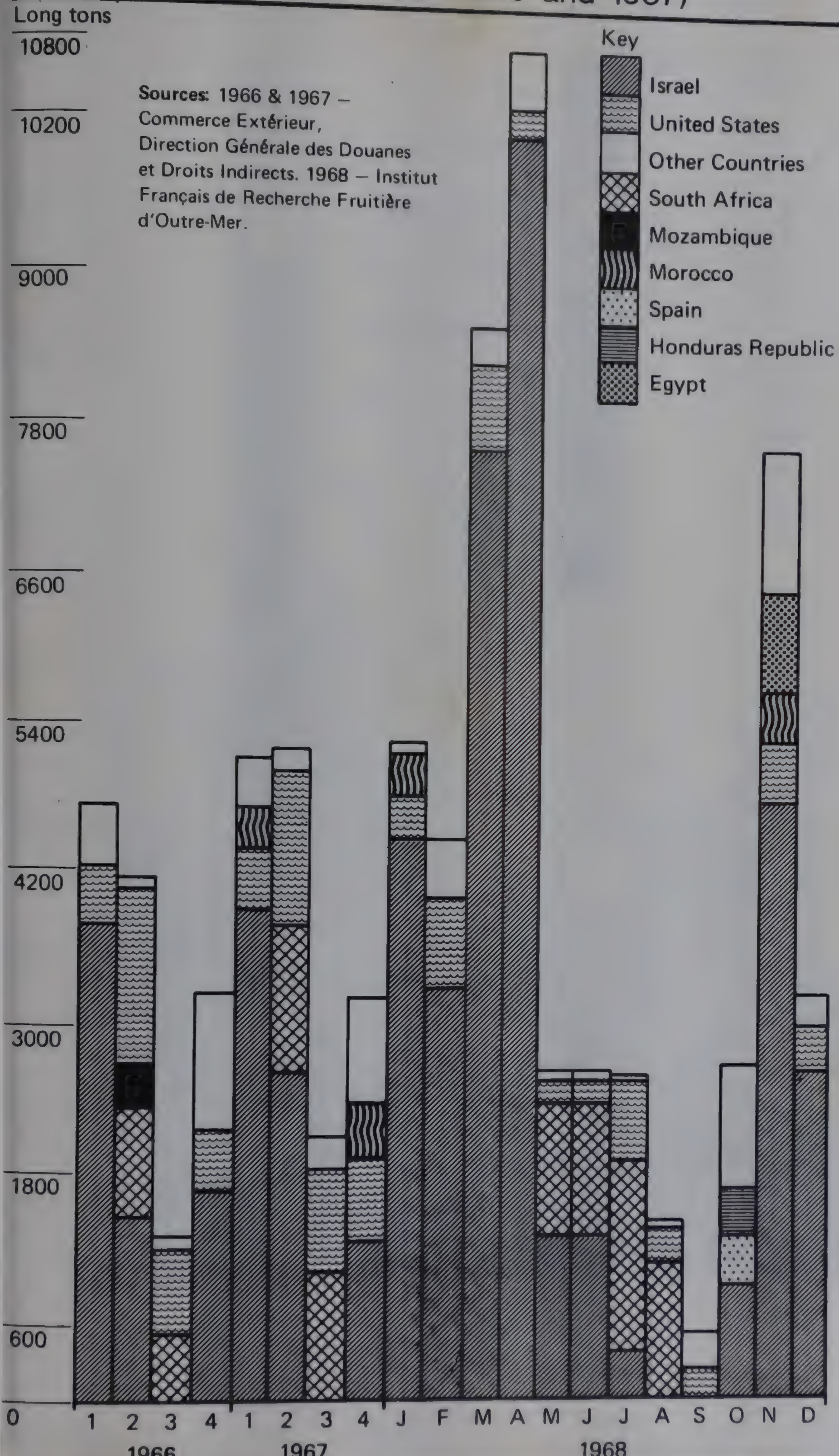
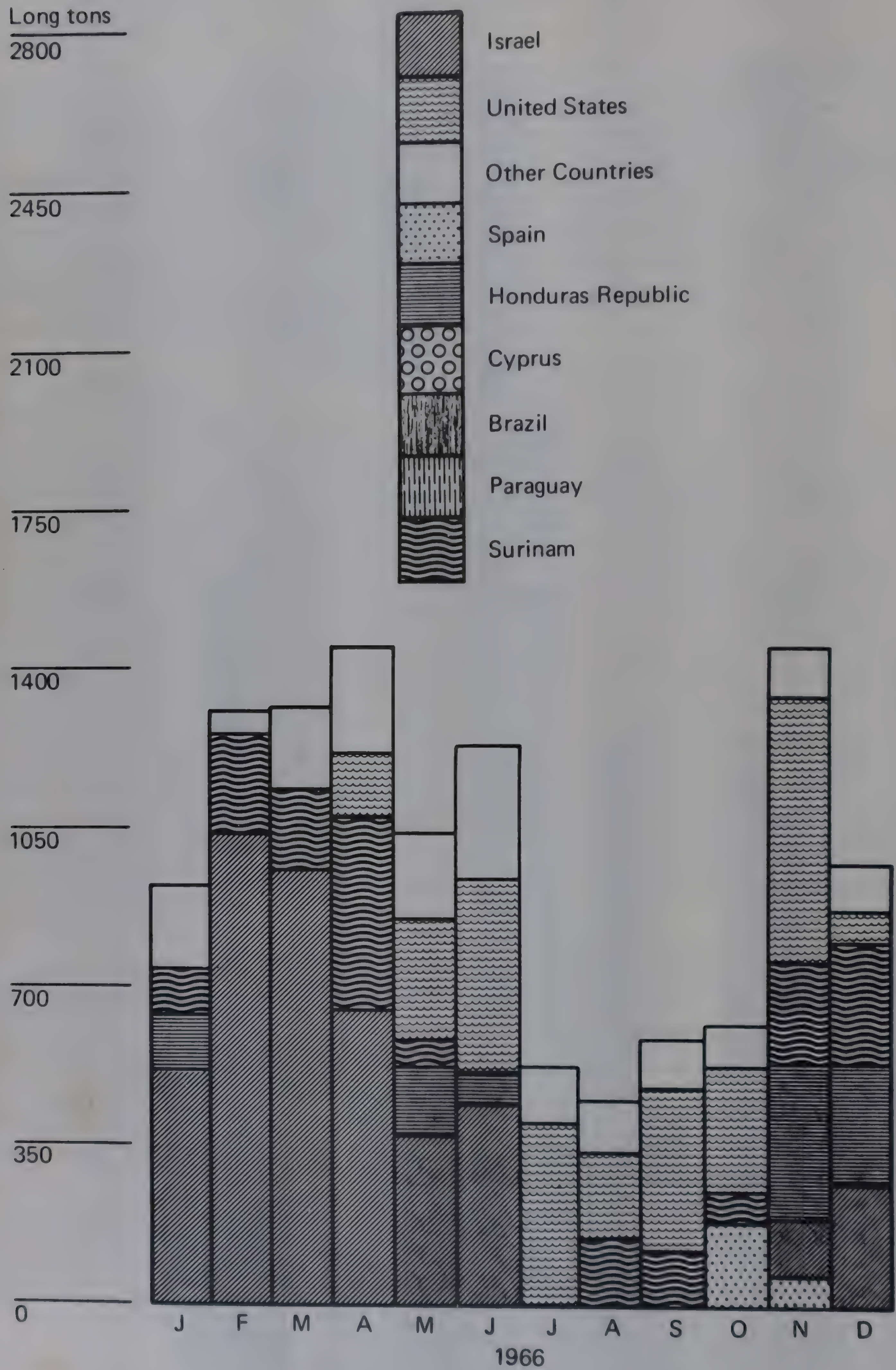


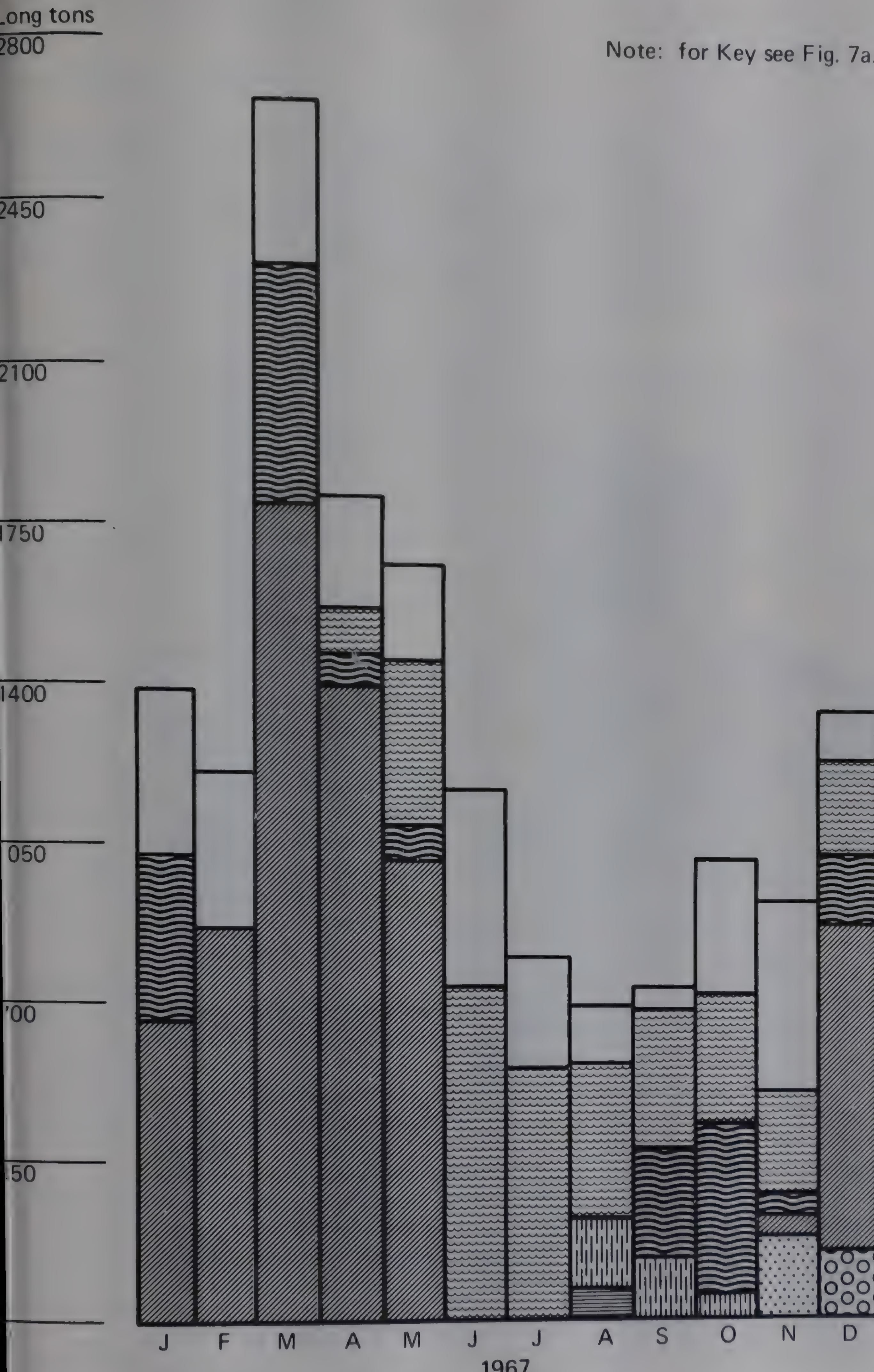
Figure 7a
Grapefruit Monthly imports into the Netherlands 1966



Source: Maandstatistick van de In-Uit-Voer
Centraal Bureau voor de Statistick.

Figure 7b

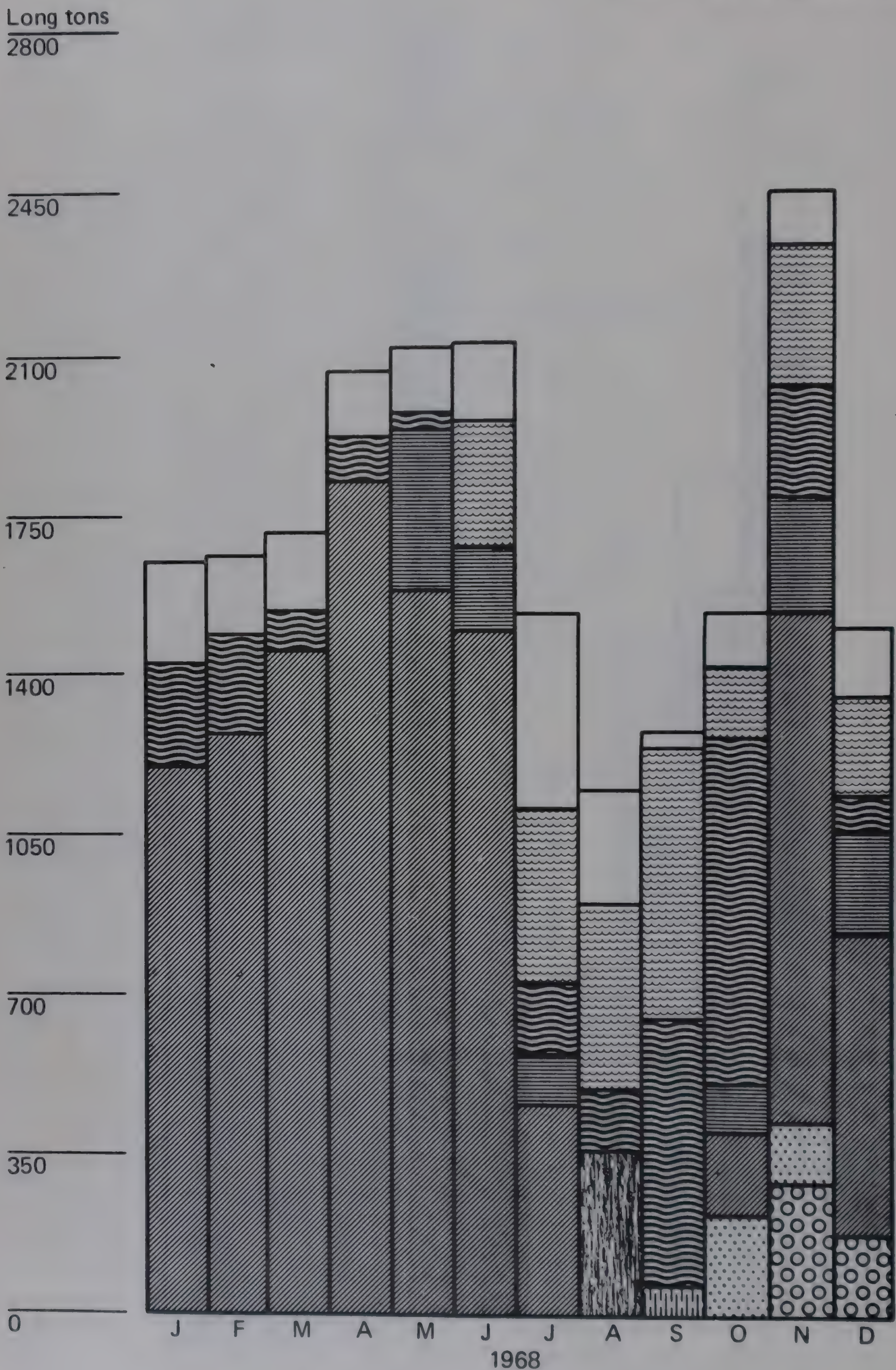
Grapefruit Monthly imports into the Netherlands 1967



Source: See Fig. 7a.

Figure 7c
Grapefruit Monthly imports into the Netherlands 1968

Note: for Key see Fig. 7a.



Source: See Fig. 7a.

October until December. Surinam supplies the Netherlands' market throughout the year, although only small quantities are available from this source in June.

Belgium/Luxembourg

Before the Second World War this country was the largest market for fresh grapefruit in Continental Europe, importing 8,800 tons in 1938, in spite of its relatively small population. However post-War consumption of grapefruit did not recover to the 1938 level until 1965. Over the period 1957-59 to 1968 imports rose from an average of 6,215 tons in 1957/59 to 11,880 tons in 1968, an increase of 91 per cent (see Table XI of Appendix D).

Unfortunately the Belgian Trade Returns do not show the minor supplying countries. Israel has been the major supplier throughout the period, accounting for 42 per cent of supplies in 1957/59 and for 73 per cent in 1968. The other major supplier is the United States, whose share of the market fell from 42 per cent in 1957/59 to 25 per cent in 1967 (imports from the United States are not shown separately in 1968). Until 1965 at least, substantial quantities of grapefruit were received from the Netherlands (6 per cent of the total in 1965) and from 1966 to 1968 a large proportion of grapefruit received from "other countries" was imported from other EEC countries.

The seasonal distribution histograms for imports during 1966, 1967 and 1968 (Fig. 8) show a strong peak during the spring months, March and April, in 1966 and 1967 although in 1968 imports were at their highest in May. Imports are at a relatively low level from July until December, being at their lowest in October. Israel dominates this market from November until May or June. The United States was an important supplier during September, October and November in 1966 and 1967, and probably accounted for a large proportion of the "other countries" supplies during the earlier months of 1966 and 1967 and perhaps also in 1968.

Switzerland

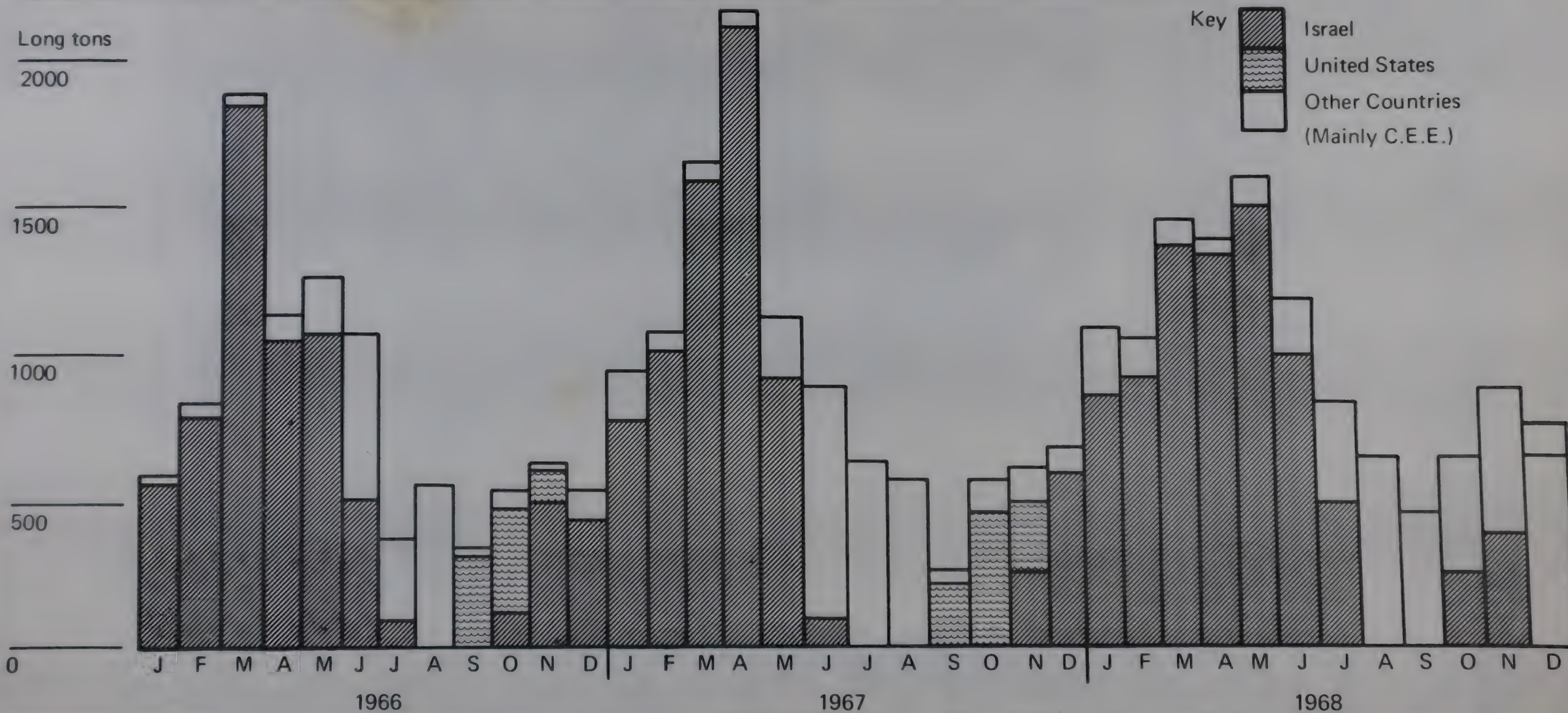
Swiss imports of grapefruit showed a gradual increase in the post-War period but the rise in imports over the period 1960 to 1968 amounted to only 37 per cent and did not show a steady upward trend - in fact imports were higher in 1967 than in 1968 (see Table XII of Appendix D).

Israel was the major supplier of the Swiss market throughout the period under review, accounting for 71 per cent of imports in 1960/62 and for 74 per cent in 1968. In 1960/62 the United States supplied 18 per cent of the market and South Africa 5 per cent, whereas in 1968 imports from the United States (which were considerably lower than in previous years) accounted for only 3 per cent of the total, imports from South Africa for 9 per cent, while imports from Cyprus supplied 11 per cent of the market. Minor suppliers include Spain, Brazil and Mozambique.

Figure 8

Grapefruit Monthly imports into Belgium/Luxembourg 1966-68

Source: Commerce Exterieur L'Institut National de Statistique



The histograms of monthly imports for 1966, 1967 and 1968 (fig. 9) show a very low level of imports during the summer months (May or June to September or October) following a peak during the spring months (February to April). Israel is the major supplier during the winter months, October or November until April or May, while Spain contributes small quantities from October to December and Cyprus is an important supplier from November until January. During the summer months, May to September, South Africa and the United States supply the market, and Brazil was also of some importance in 1966 and 1967.

Italy

Italy is a minor producer of grapefruit: production amounted to 685 tons in 1967. Italian imports of grapefruit were negligible during the early years of the period under review, as the result of strict phyto-sanitary regulations which virtually limited suppliers of grapefruit to Somalia and Tripolitania (Libya). In 1957/59 Somalia supplied 99 per cent of the average 154 tons imported annually, and 78 per cent of the 313 tons imported in 1963. However since 1964 agreements have been concluded with various other exporters of grapefruit, including Israel, Venezuela, South Africa, Surinam, Cyprus and Morocco (see page 55). In 1964, 686 tons of grapefruit were imported, and in 1968, 6,498 tons - an increase of 847 per cent over four years(see Table XIII of Appendix D).

The latest year for which detailed statistics are available is 1967, when Israel supplied 67 per cent of imports, South Africa 25 per cent, Somalia 3 per cent and Venezuela 2 per cent. In 1968 Israel increased her share of the market to 83 per cent.

The Italian phyto-sanitary regulations which limit importation of grapefruit from certain countries to various periods of the year, obviously affect the seasonal distribution of imports (see page 55). Quite part from this, Italian imports were subject to wide fluctuation from month to month in 1967 and more particularly in 1968 (see Fig. 10). Two possible explanations for these fluctuations are - in the first place, once an unusually large consignment of fruit has been received, import requirements for the following month will be reduced; secondly, a large consignment may be destined, in whole or part, to be re-exported to other European countries.

Scandinavia

The four mainland Scandinavian countries (Denmark, Finland, Norway and Sweden) import relatively small quantities of grapefruit considering the size and wealth of their populations (a total of 11,670 tons in 1967). Moreover the rate of increase of imports over the period 1957 to 1967 was less than that in many other European countries, being 101 per cent in Denmark, 129 per cent in Finland, 87 per cent in Sweden and only 34 per cent in Norway. Imports into Denmark, Sweden and Norway fell in 1968, possibly as the result of reduced supplies from the United States - one of the major suppliers to the Scandinavian countries.

Figure 9
Grapefruit Monthly imports into Switzerland 1966-68

Source: Statistique de la Suisse, Bureau Federal de Statistique

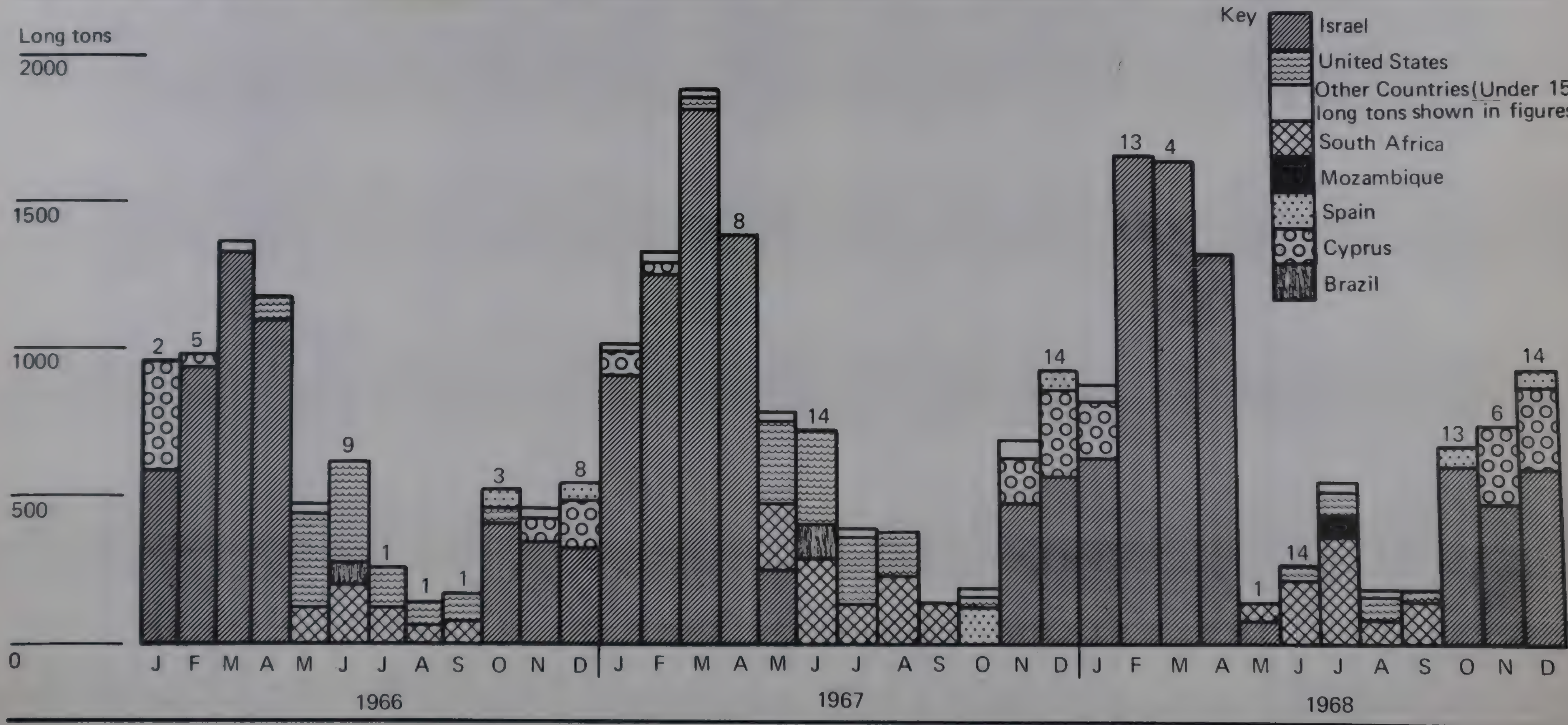
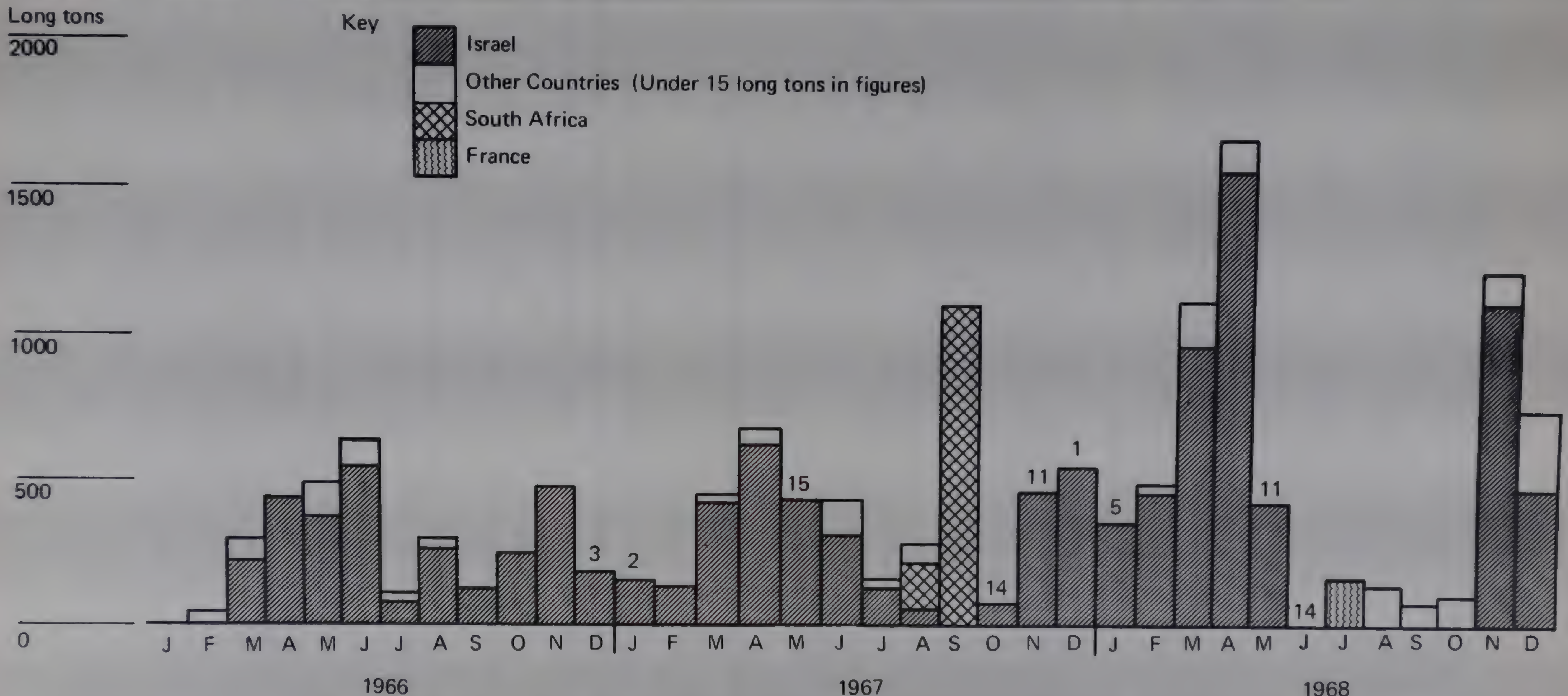


Figure 10

Grapefruit Monthly imports into Italy 1966-68

Source: Comercio con L'Estero Instituto Centrale di Statistica.



Israel was the most important supplier of grapefruit to all four countries in 1967, accounting for 50 per cent of imports into Denmark, 77 per cent in Finland, 55 per cent in Sweden and 45 per cent in Norway. The United States was the second supplying country for Denmark, Norway and Sweden, accountin for 14 per cent, 32 per cent and 36 per cent respectively of these countries' imports in 1967, but for only 6 per cent of Finland's imports. South Africa was the other important supplying country, and in 1967 supplied 6 per cent of Danish imports, 15 per cent of Finnish, 15 per cent of Norwegian and 3 per cent of Swedish imports. Only Denmark imports significant quantities of grapefruit from Cyprus (10 per cent of the total in 1967) and from the Caribbear the Honduras Republic has been an important supplier of this market since 1964 and in 1967 supplied more than 11 per cent of Danish imports.

Unfortunately monthly import data are available only on a gross basis for Denmark, Norway and Sweden although a quarterly break-down by supplying country is available for Sweden. No monthly or quarterly import data is available for Finland. The monthly import figures show the usual seasonal pattern with a peak in February and March and a low level of imports during the summer months with imports being at their lowest in September and October. The Swedish quarterly figures show that imports from Israel are at their peak during the first quarter, while the United States is a major supplier throughout the year and South Africa and Brazil supply the market during the second and third quarters. In 1968 small consignments were received from British Honduras, the Honduras Republic and Cuba during the final quarter.

Quality and Packaging Requirements In International Trade

Quality Factors

The principle criterion of the quality of grapefruit is firmness. The skin should yield slightly when handled, but it should not feel soft or pulpy. In addit the fruit should be well-rounded and not pointed and the skin should be unblemished and have a bright colour - greenish-coloured fruit generally sell at a discount on European markets. The flesh should be juicy and not too acid, and it is an advantage if the rind is thin.

Many producing countries have minimum standards of maturity below which the fruit should not be harvested. These standards are based on the total solids content of the juice and the ratio between this and its acidity. Details of the maturity standards operating in Florida as published in the State of Florida Citrus Fruit Laws are given in Appendix C of this report. Immature grapefruit should never be exported since consumers could be adversely influenced against the fruit.

The United Nations Economic Commission for Europe has prepared a European Standard for citrus fruit moving in trade between European countries which is set out in the appendix of this report. This sets a minimum juice content of 35 per cent for grapefruit and prohibits the importation of grapefruit smaller than 70 mm in diameter. Greenish-coloured grapefruit are permitted providing they meet the minimum juice content requirement (see Appendix A).

Generally speaking the pink and red-fleshed grapefruit varieties are not well-known on European markets and meet with considerable consumer resistance in some countries, in spite of their popularity in North America, where their flavour is considered outstanding. Nevertheless, in recent years American exporters have established outlets for red-fleshed grapefruit in Sweden and Germany where certain buyers will pay a premium for this fruit.

On the whole desert-type grapefruit meet the requirements of European markets better than tropical-type fruit, particularly as regards unblemished skin and long shelf-life (at least a month in the importing country is the ideal). However there appears to be little prejudice against tropical grapefruit in the Netherlands and in recent years a distinct market for this type of grapefruit has been developed in France and Germany.

Harvesting and Packing

In many countries the time of harvesting is determined by maturity tests on the fruit (as mentioned above) which are frequently carried out by government inspection services. However the acidity of grapefruit may be reduced, and hence the time of harvest be brought forward by one to two months, by use of lead arsenate sprays about four weeks after bloom (36). This is common practice in Florida and trials in Trinidad using lead arsenate in a concentration of 1 lb. to 100 gallons of water have shown that earlier harvesting is also possible under tropical conditions. The use of lead arsenate sprays on grapefruit does not seem to affect the quality of the fruit adversely, although the quality of oranges and tangelos can be drastically reduced by the use of such sprays.

The fruit should be carefully clipped from the tree and gently handled during all harvesting and packing operations. It has been found that tropical-type fruit, especially that grown in coastal regions and on old trees, is very susceptible to bruising, particularly towards the end of the harvesting season and this increases the incidence of blossom-end-clearing or water-logging. (37)

Grapefruit for export should be carefully graded for size and quality. Grading standards vary a good deal from one country to another, but producers exporting to European countries are increasingly using the European Standard for imported grapefruit (see Appendix A) as a basis for their export grades. This means that there are two basic quality grades (classes I and II of the European Standard) and nine size grades, ranging from 70 to 75 mm diameter to 114 to 122 mm diameter. The Standard also covers packaging and presentation of grapefruit and marking on the packages.

In fact the different sizes of grapefruit are usually referred to by the "count", or average number packed in a standard box. The most favoured counts on European markets are 40, 48 or 56 per 15 Kg container although buyers in the United Kingdom will take fruit as large as 32 or 27 per 15 Kg container and buyers in the Netherlands will take fruit as small as 64 or 75.

It is usual to protect grapefruit for export from attack by moulds by treating them with a fungicide such as diphenyl or sodium ortho-phenylphenol (SOPP). Diphenyl (or biphenyl) is the chemical most widely used for this purpose - the fruit may be wrapped in diphenyl-impregnated tissue, or impregnated pads of paper may be placed in the box or carton. The chief disadvantage of diphenyl is its rather unpleasant odour. Importing countries restrict the quantities of diphenyl residue on imported fruit - the maximum permitted levels are 100 ppm in the United Kingdom, United States and many other importing countries and 70 ppm in member countries of the EEC. The lower level permitted in EEC countries does not always provide sufficient protection against fungal attack.

SOPP is used chiefly on citrus intended for consumption in the producing country (the main users are the United States and Australia). This fungicide can be applied as a spray or dip, but like diphenyl has a rather unpleasant odour. The maximum permitted residue level on citrus fruit is 70 ppm.

Another chemical which has been used as a citrus fungicide in Australia is thiabendazole (TBZ). This has the advantage over diphenyl and SOPP of being odourless and simple to apply in solution as a spray or dip. At present exporting countries are conducting trials to determine whether the maximum residue level of 2 ppm permitted in most Western European countries and the United States will give sufficient protection under commercial conditions. The use of TBZ as a fungicide is not yet permitted in the United Kingdom.

Grapefruit are sometimes waxed to reduce desiccation and maintain their fresh appearance.

At the beginning of the harvesting season when the fruit is mature but not yet fully coloured the fruit may be degreened by the use of ethylene gas at a temperature of 85°F (29.5°C). This process is normally carried out before waxing. Alternatively, Florida grapefruit has been shipped unwaxed at 60° to 70°F (15.5° to 21°C) and it was found that the fruit degreened naturally during a three-week voyage (38). The use of colouring agents is prohibited for fruit sold on European markets.

Both fibreboard cartons and "Bruce" boxes (wooden wire-bound boxes) are used for the export of grapefruit. The old heavy wooden citrus case is no longer used in international trade. Cartons are favoured by most retail buyers because they cause fewer problems of disposal. However cartons have certain

draw-backs from the exporter's point of view in that their ventilation is poor, the fibreboard tends to absorb moisture and may collapse, and the humid atmosphere inside the carton encourages fungal growth. It is generally accepted that a consignment cannot consist solely of fruit packed in cartons because the latter do not have sufficient "stacking-strength" to be stacked to the top of a ship's hold. Thus in every consignment the lower layers of containers in the hold must be Bruce boxes. Where cartons are used the telescopic type are usually favoured for their greater strength.

In recent years there has been a trend towards the use of smaller containers for fruit as more fruit has been sold through supermarkets where female labour is widely employed. The most usual sizes of container for grapefruit are the 15 Kg (used in South Africa, Morocco, Jamaica and Dominica), the $16\frac{1}{2}$ Kg (used in California) and the 20 Kg container (used in Israel and Cyprus). The individual containers are frequently palletized to reduce unnecessary handling, but the lay-out of freight holds does not always permit palletization.

Grapefruit should be shipped in ventilated or refrigerated holds, in the latter case they are usually carried at 52°F (11°C). Rapid cooling of the fruit to their shipping temperature, helps to reduce waste and to maintain the quality of the fruit. However it has been shown that temperatures below 50°F (10°C) cause rind-pitting in Florida (tropical type) grapefruit. (38)

Refrigerated bulk containers have not yet been used commercially for shipment of grapefruit although a consignment of boxed oranges shipped in containers from Australia to Europe met with a very favourable response. Experiments in Florida and Texas also suggest that the use of controlled atmosphere storage (ie the atmosphere in the container has a low, controlled, oxygen level) prolongs the storage life of grapefruit. (39) Thus the commercial adoption of refrigerated, controlled atmosphere containers is a distinct possibility and could be used to extend the marketing seasons of the major suppliers of grapefruit even further. At present Israel and South Africa both employ cold storage in importing countries to extend their marketing seasons by four to eight weeks. However the trade has commented adversely on stored South African fruit which has on occasion suffered considerable wastage from stem-end and blossom-end rots.

Barriers to Trade

Tariffs, quotas and phyto-sanitary (plant health) regulations may limit, or indeed completely prevent trade in fresh fruit. However, generally speaking grapefruit is now subject to fewer restrictions on trade than many other fruits, although the United Kingdom's discriminatory quotas, and the Italian phyto-sanitary regulations still constitute substantial barriers to trade in grapefruit. In addition to tariffs many continental European countries levy a turnover tax on all goods, thus raising retail prices.

The EEC countries do not have a reference price system for grapefruit imports.

Tariffs and Internal Taxes

Table 3 shows the rates of duty and internal taxes levied on grapefruit imported into Western European and North American countries, as of December 1969. It will be noticed that under the Kennedy Round of tariff concessions, import duties will be reduced considerably by 1972. Under these provisions grapefruit imported into the Scandinavian countries will be free of duty by 1972 and imports into the EEC countries will be charged a duty of 6 per cent ad valorem. Of the countries charging specific import duties only the United States is reducing the rate of duty. The ad valorem equivalents of the British and Swiss General Tariffs were about 7 per cent and 6 per cent respectively on average in 1967, but it is difficult to determine the equivalent rates for Canada and the United States since their trade statistics show values of imports in fob terms.

The exceptions to the General Tariff are of greatest importance in Canada and Switzerland since most exporting countries enjoy the British Preferential or Most Favoured Nation Tariffs in trading with Canada, or are members of GATT and thus qualify for the reduced rate of duty in trading with Switzerland. The British Commonwealth Preference affects a substantial proportion of grapefruit imports, but the free entry granted by the EEC countries to their respective former dependencies are of importance only to the Netherlands who imports a large proportion of her grapefruit requirements from Surinam. The exceptions to the United States' tariff are of little relevance at the present time since trade with Cuba has been suspended and the Eastern Bloc countries do not export grapefruit.

Internal taxes levied on grapefruit are highest in the Scandinavian countries and Belgium, particularly in the latter where the transmission tax amounts to 14 per cent of gross landed value. Provincial and State sales taxes in North America usually range from 3 per cent to 6 per cent of the retail price. In Switzerland and the United Kingdom most foodstuffs are exempt from internal taxation.

Quotas

Among the importing countries considered here only the United Kingdom imposes quotas on the importation of grapefruit. Imports from the Dollar Area (comprising the United States, Canada, the Central American countries, Haiti and Liberia) excluding Cuba, are permitted only from 1st December to 30th September (prior to 1968/9 only from 1st March to 30th September) and are limited to a value of £1,150,000 cif. In fact this quota has never been filled. There is a separate quota for imports from Cuba of $70,000 fob annually. Import licences are required for imports from these countries. The main purpose in retaining the Dollar Area quota is to protect the West Indian grapefruit industries from potential competition.

Tariffs and Internal Taxes Levied on Fresh Grapefruit in Selected Countries

Country	General Tariff	Kennedy Round Concessions	Exceptions to General Tariff	Internal Taxes
Canada	1 cent per pound	-	British Preferential and Most Favoured Nation Tariff - Free	Provincial sales taxes at retail level
Denmark	3 per cent ad valorem	Free of duty by 1.1.72	-	Value-added tax 12.5 per cent ad valorem
European Economic Community	9.6 per cent ad valorem Reduced to 7.2% ad valorem until 30.6.70	To be reduced to 6 per cent ad valorem by 1.1.72	Produce from Associated African and Malagasy States, overseas territories and former dependencies - Free	Belgium 14% of gross landed value France 7.52% of gross landed value Germany 5.5% " " " " Italy 6.4% " " " " Luxembourg 3% " " " " Netherlands 4% " " " "
Finland	4 per cent ad valorem	Free of duty by 1.1.72	-	Turnover tax 12.4% of import value
Norway	1.33 Kr. per 100 Kg. net	1.33 Kr. per 100 Kg. net	-	Sales tax 12% of retail price
Sweden	Free	Free	-	Value-added tax 11.11% ad valorem
Switzerland	5 fr. per 100 Kg. gross	-	G.A.T.T. tariff rate 3 fr. per 100 Kg. gross	-
United Kingdom	5s. 0d. per cwt. net	-	Produce from Commonwealth, South Africa and Burma - Free	-
United States	1. 8-30. 9. 1.1 cents per pound 1.10-31.10. 0.85 " " " 1.11-31. 7. 1.4 " " "	1.0 cents per pound 0.8 " " " 1.3 " " "	Cuba* / Eastern Block 0.3 c. per pound / 1.5 c. per pound 0.6 " " " / 1.5 " " " 1.2 " " " / 1.5 " " "	State sales taxes at retail level

*Suspended since 1961.

Phyto-sanitary Regulations

The phyto-sanitary regulations applicable to grapefruit imported into Western European and North American countries are summarised in Table 4 on page 55. Most importing countries require consignments of grapefruit to be accompanied by a general plant health certificate issued by the Plant Protection service of the exporting country to certify the consignments' freedom from dangerous pests and diseases, in particular the Mediterranean fruit fly. The purpose of these regulations is, of course, to prevent the introduction of pests and diseases into countries where they are not endemic. Even when a consignment is accompanied by a health certificate it is liable to be thoroughly examined by the plant health officers of the importing country, and if any infestation is discovered the consignment may be destroyed.

The Italian plant health regulations differ from the others in discriminating between exporting countries and allowing imports only at certain times of the year. In principle imports of citrus into Italy are banned, but individual exporting countries may apply for a waiver of the regulations during a part or the whole of the year and these waivers are renewed annually. Imports from certain countries, such as Morocco and Cyprus, are permitted only after fumigation in the country of export.

Several countries charge a fee for the phyto-sanitary inspection at the port of discharge. These charges are as follows:-

France	0.7 per cent ad valorem	
Germany	D M 2.0 for 1 metric ton or less D M 1.20 for each additional ton or fraction thereof	
Sweden	1.4 to 30.9	0.30 Knr per 100 Kg (minimum 12 Knr per consignment)
	1.10 to 31.3	No charge

TABLE 4

Phyto-Sanitary Regulations for Imported Grapefruit in Selected Countries

Country	Regulations
Belgium	General Health certificate
Canada	No certificate required. Fruit must be packed in new containers
Denmark	No certificate required
France	General Health certificate
German Federal Republic	General Health certificate
Italy	Imports only permitted from:- Libya 1.10 to 31.3 each year Somalia) Venezuela) all year Israel 1.1 to 31.12, 1969 South Africa 1.7 to 31.10, 1969 Surinam 1.8 to 31.10, 1969 Morocco*) Cyprus*) 1.10.68 to 31.3.69 General Health certificate

* each consignment to be disinfected with Methyl bromide under vacuum at place of origin

Country	Regulations
Netherlands	Health certificate required in respect of Mediterranean fruit fly (*Ceratitis capitata*)
Norway	General Health certificate
Sweden	Health certificate required in respect of Mediterranean fruit fly (inspection to take place not more than 15 days before despatch). Fruit must be packed in new containers
Switzerland	No certificate required
United Kingdom	No certificate required
United States	An import permit is required which will show whether or not a health certificate is required. All consignments are subject to inspection and disinfection on arrival.

PART III

MARKETS FOR GRAPEFRUIT

In this section the different market structures, demand patterns and price levels in the major world markets for grapefruit are discussed. On the whole the most important markets for grapefruit are the importing countries - the one exception is the United States - by far the largest market for grapefruit in the world. Although the United States is self-sufficient in that imports are negligible at present, this huge market can hardly be ignored and may give some indications as to future trends in consumption in European markets.

It should be noted that wherever prices have been converted to sterling an apparent 15 per cent rise occurs in 1968 values over those of 1967 as a result of the sterling devaluation towards the end of 1967.

The United States Market for Grapefruit

As might be expected, per capita consumption of fresh grapefruit is higher in the United States than in any other country (with the single exception of Israel) in spite of competition from processed grapefruit. The peak of fresh grapefruit consumption was reached just after the War: since that time grapefruit juice and canned or chilled segments have made inroads into the fresh fruit market. Nevertheless, after falling to a low of 6.4 lb per capita in 1963, fresh grapefruit consumption rose steadily to 9.0 lb in 1967 when supplies were unusually high and prices low, before falling again to 8.0 lb in 1968, when there was a short crop.

The size and geographical distribution of the United States' population contribute to the complexity of marketing grapefruit, which is chiefly produced in the extreme south-east of the country, whereas the main centres of population are situated in the north-east and on the west coast. Information concerning grapefruit marketing is available in a survey undertaken in 1961 by the Economic Research Service of the US Department of Agriculture, in eight terminal wholesale markets situated in the Central and Western States(40) This study found that the largest handlers of grapefruit, namely receivers (primary wholesalers), national and regional chain stores, and brokers, obtained their supplies from the production areas, either direct from the shipper, through their own salaried buyer (in the case of chain stores) or occasionally through a broker in a production area. Grapefruit was usually bought firm on an "fob production area" basis or on a "delivered" basis - consignment/commission sales were of relatively little importance. Substantia quantities of grapefruit handled by brokers did not physically move through the terminal markets but were diverted directly to buyers in smaller markets. There can be few importers who handle grapefruit in the United States but it is interesting to note that South African citrus has been marketed by a Florida citrus co-operative during the summer months.

The wholesale trade in fresh fruit in general is declining as the large chains take more of the retail market and buy their requirements direct from the shipping firms.

Chain stores are the major outlet for fresh grapefruit in the United States. Although national and regional chains maintain their own buyers in production areas, they purchase some of their requirements from wholesale firms in the terminal markets. Local chains obtain most of their requirements through the wholesale markets. Catering outlets are of little importance in the fresh grapefruit trade, since canned grapefruit segments and chilled or frozen juice are easier to serve than the fresh fruit. Individual retailers are now of little importance.

The major markets for grapefruit in order of importance in 1968 were New York City - Newark, Los Angeles, Pittsburgh, Chicago and San Francisco - Oakland (41). These markets serve the densely populated areas of the North Eastern states, Mid-West and California. Auctions are held in New York, Pittsburgh, Chicago and in several small markets in the north-east, by far the most important being the New York auctions. However auctions have been of decreasing importance in recent years and accounted for only 9 per cent of sales at terminal markets in the 1967/8 season (42).

On the American market fresh grapefruit competes chiefly with processed citrus products, both segments and juice, as a starter to a meal (chiefly breakfast), or as a quick snack. During the spring and early summer months there may be some competition from fresh berry fruits and during the late summer from melons. However domestic supplies of fresh grapefruit are very limited during the months June to September when demand is presumably met by canned grapefruit (it should be remembered that Florida grapefruit is not stored on a commercial basis for longer than a couple of weeks). Thus it appears that imported grapefruit might perhaps find a market during the late summer months, so long as exporting countries could meet the stringent American phyto-sanitary regulations, which hitherto have been the main obstacle to sales of imported citrus in the United States. The regulations vary according to the pests endemic in the producing areas. South African citrus fruit, for example, was only permitted entry after fumigation throughout the month-long voyage from South Africa to New York.

Prices and Margins

Detailed price data is available only for Florida grapefruit; average returns for Californian grapefruit are higher, particularly for summer fruit (43).

Prices paid for fresh grapefruit on the United States market are influenced chiefly by available supplies (crop forecasts are widely published in the United States). Thus average on-tree returns over the season were high in 1963/4 and 1967/8 ($2.62 and $2.52 per 85 lb box, respectively) when crops were short, and low in 1966/7 ($1.21 per box) when the crop was an unusually large one. However, the seasonal pattern of prices for Florida grapefruit does not always follow the pattern that might be expected ie high prices at the beginning of the season in October, followed by a fall to a low in February and March and possibly a recovery towards the end of the season in May and June. In fact this expected

trend of prices was followed in only two of the last five seasons (1964/5 and 1966/7). In the other three seasons prices rose steadily from October or November until the end of the season. This unusual price trend could be explained by the poor crops in 1963/4 and 1967/8 - prices rose as it became obvious that supplies would be limited. Although 1965/6 was not a short crop year, an unusually high percentage of the Florida crop was sold during the months October to December and a smaller percentage of the total crop than usual was sold on the fresh market (44).

As regards prices for grapefruit grown in other areas, although there is no monthly data available, it is reasonable to suppose that prices reach a peak in the months July to September when only limited supplies are available.

As might be expected, seedy grapefruit are sold at a discount on the fresh market, fetching between 20 and 30 per cent less than white seedless fruit (45). In fact seedy grapefruit is sold fresh only in the local markets in production areas. On the other hand pink and red-fleshed seedless grapefruit fetch a premium over white-fleshed fruit - up to 12 per cent on average in recent seasons (46). The American market generally prefers large grapefruit, the smaller sizes being exported or processed.

Prices at auctions in the main terminal markets average between two and three times the on-tree price per box (47) - a large proportion of this difference is accounted for by packing and transport costs. The highest average prices are obtained at Chicago, New York and Detroit auctions, but this may be because a larger proportion of high-quality and pigmented fruit is sold at these auctions.

The Canadian Market for Grapefruit

Per capita consumption of grapefruit is very nearly as high in Canada as in the United States and, not surprisingly, has followed the same trend in recent years, reaching 8.9 lb per capita in 1967.

The Canadian population is even more concentrated geographically than the American - a large proportion of the population live in the extreme south-east of the country, around the Great Lakes, with a smaller concentration on the West Coast. This distribution of population, however, facilitates the import of grapefruit from Florida in the East and from California and Arizona in the West. The largest terminal markets in order of importance are Toronto, Montreal, Vancouver, Winnipeg and Ottawa (48). All American grapefruit is received overland by rail or truck. Grapefruit imported by sea is received at the Eastern ports of Montreal and Toronto.

As in the United States, chain stores are the major outlet for fresh grapefruit and the wholesale markets are declining in importance.

Prices

Regrettably a wholesale price series is not available for grapefruit sold on Canadian markets. Import values shown in the Trade Returns are subject to the reservation that the values of some consignments may have been quoted in fob terms although it is assumed that cif terms are usually quoted by importers. Average import values for the last three years are shown in the table below:

	1966	1967	1968
		Shillings per cwt	
United States	44s	38s	61s
South Africa	34s	52s	57s
Cuba	40s	80s	54s
Mexico	47s	-	81s
Brazil	-	-	33s

Source: Trade of Canada, Dominion Bureau of Statistics

Values for imports from Jamaica cannot be calculated with any accuracy because of the small quantities involved; however these appear to be relatively high - of the order of 90s to 100s per cwt. These high values are the more surprising because Jamaican grapefruit arrive on the Canadian market during the spring months, when there are large supplies available from the United States. Mexican and Cuban fruit reaches the Canadian markets during the autumn months when prices may be expected to be relatively high. Brazilian and South African grapefruit, though available when supplies from the US are at their lowest, may have deteriorated in quality after a long voyage and also compete with summer deciduous fruit and berries.

The United Kingdom Market for Grapefruit

Grapefruit consumption on a per capita basis has always been higher in the United Kingdom than in any other European country with the exception of Switzerland. Consumption has exceeded 3 lb per head since 1964 and in 1966 actually reached 3.7 lb per head, although 1969 is certain to see a decline from this figure since supplies were unusually limited.

The primary wholesale markets in the United Kingdom are all situated within 100 miles of a port, many of them being situated at large ports, for example London, Liverpool, Bristol, Hull, Glasgow and Belfast. It is general practice for major exporters of grapefruit to use several ports of discharge and thus to minimise the inland journey by rail or truck. Labour troubles in the docks at London and Liverpool, in particular, have encouraged the use of small ports such as Sheerness and Cardiff which can guarantee the quick turn-round of a vessel.

Importers almost invariably handle grapefruit on a consignment/commission basis. Only large chain stores buy firm from the exporting countries or their agents. An increasing proportion of sales in the wholesale markets are made by private treaty, although auctions are still of some importance in Liverpool, Hull, Glasgow and Spitalfields Market (London). South African grapefruit is no longer auctioned and only small quantities of Israeli grapefruit are sold through the auctions.

The independent greengrocer is still an important outlet for grapefruit in the United Kingdom, particularly in the North and West of the country where chain-stores are not so numerous and tend to handle only the basic fruits and vegetables. However supermarket chains have become increasingly important outlets in recent years, particularly in London and the South East. At one time the high-class hotel and restaurant trade was a major outlet for grapefruit but the increasing acceptance of processed forms of grapefruit, which save labour and permit strict portion control, has reduced catering demand for the fresh fruit.

There is no demand for pink or red-fleshed grapefruit on the United Kingdom market except in the Blackpool area. In general pigmented grapefruit have to be sold at a discount on markets other than Liverpool, because the general public imagines the coloured flesh to be diseased - a large-scale advertising campaign would probably be necessary to eradicate this opinion. Similarly, the brown skin markings typical of tropical grapefruit are frequently considered an indication that the fruit is bad, although some salesmen are of the opinion that consumers are now beginning to accept these markings. However there appears to be no specialised demand for tropical grapefruit as such, as there is in some other European markets. The sizes of grapefruit preferred on the United Kingdom market are counts 40 and 48 for the retail trade, 32 or larger for the catering trade. There appears to be a trend towards the larger sizes of grapefruit. However, size preferences depend very much upon prevailing prices, since grapefruit are invariably sold by the piece and, particularly in chain stores, retail prices are held constant while the size of fruit is varied.

Grapefruit is almost invariably used as a "starter" to a meal - breakfast in particular, thus it does not compete directly with other fresh fruits, - except possibly melons - the main competing products are canned grapefruit segments, and to a lesser extent, canned and frozen fruit juices. Demand might be expected to be greatest in the summer months but supplies of fresh grapefruit are limited then and not always of good quality. During the winter months breakfast cereals and porridge are widely consumed for breakfast, although slimming diets have probably stimulated demand for grapefruit in recent years.

Prices and Margins

The average cif prices for imports of fresh grapefruit over the last six years are tabulated below. These are values as reported in importers' declarations to Customs and are exclusive of any duty payable.

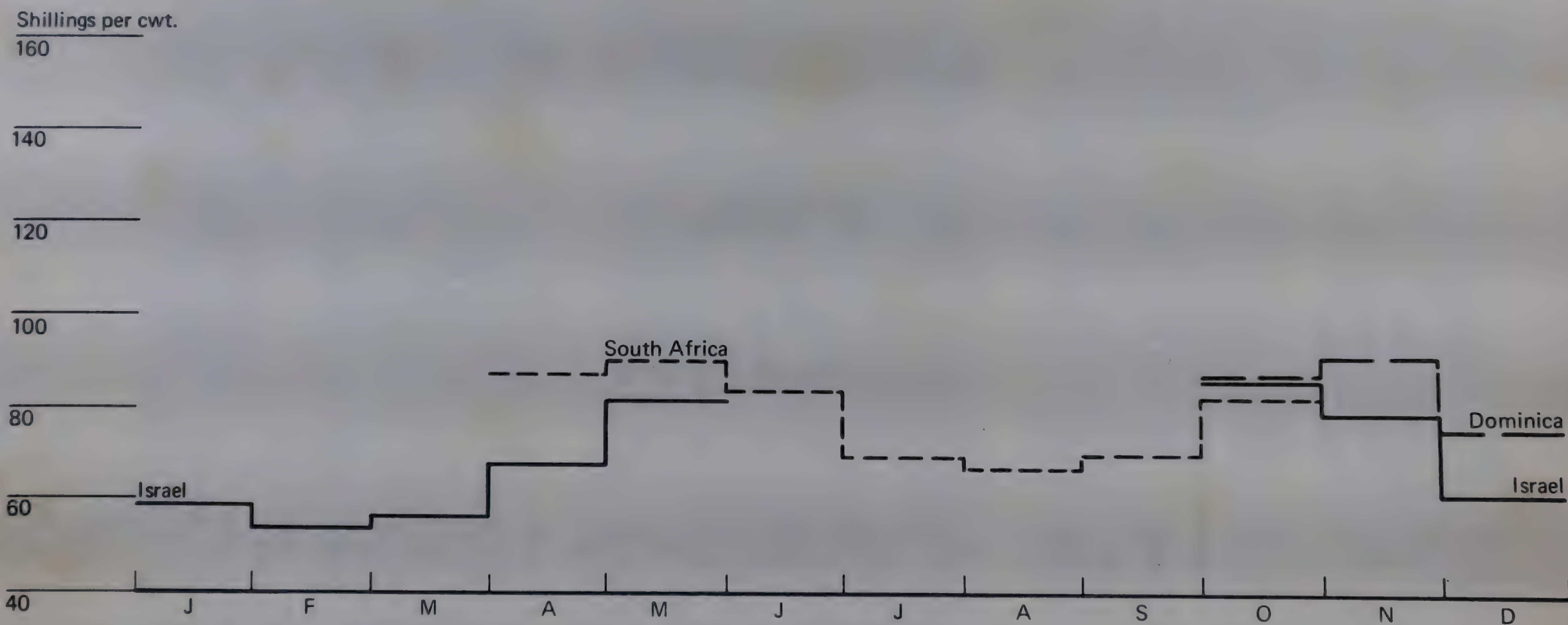
	1963	1964	1965	1966	1967	1968
			Shillings and pence per cwt			
All sources	70/0	63/6	62/6	65/0	70/6	69/3
Israel	69/0	61/6	60/6	70/9	63/6	62/9
Cyprus	56/9	50/0	50/0	53/0	55/6	59/0
Dominica	37/0	37/0	35/9	34/9	37/3	32/6
Jamaica	72/3	77/6	82/6	96/0	108/6	130/6
Trinidad	59/9	57/9	48/0	41/3	47/9	47/9
United States	82/6	78/3	71/9	90/0	79/6	129/0
Swaziland	85/6	70/3	54/6	61/6	88/0	83/6
Mozambique	85/3	64/9	78/9	67/6	83/6	76/6
South Africa	77/6	72/0	73/6	67/0	83/0	86/9

After falling from a high level in 1963 when supplies were limited the average value of grapefruit imports increased from 1965 onwards in spite of the larger quantities imported - even in 1968 when imports were 14 per cent above the 1967 figure, the value per cwt fell very little. It may be seen that imports from the Southern Hemisphere countries, which arrive during the summer months, fetch higher prices than grapefruit from the Northern Hemisphere countries (with the exception of 1966). Jamaican grapefruit has the highest average value due to its favourable season in September and October when there is little competition from the main suppliers. Cyprus and Trinidad grapefruit fetch lower prices than the competing Israeli fruit. The very low average cif prices for Dominican grapefruit are probably due to mis-recording, since according to the importers, cif values have ranged from 79s 3d to 101s 0d per cwt over the last three years, reflecting the high prices for Dominican fruit at wholesale level (see fig. 11).

Average monthly wholesale prices for the last 5 years are shown in fig. 11. Three sources of supply - Israel, South Africa and Dominica, have been chosen as indicative of supplies during the winter, summer and autumn, respectively. The prices shown should only be taken as an indication of the prices prevailing in any one month, and not as a true average. The values shown in the diagram are converted to cwt for easy comparison although prices are usually quoted per case or carton. It will be noticed that prices are at their highest in August, September, October and in some seasons, November. They then fall rapidly, as supplies increase, and stay at a low level from December to March, after which a gradual recovery occurs. This pattern was not followed in 1969 when there was an unusual distribution of supplies, resulting in a severe shortage of grapefruit during the early summer months and peak prices in June and July, followed by a decline. During the autumn months each supplying country enjoys high prices at the beginning of their season (in most cases somewhat above those of the out-going South African

Figure 11a

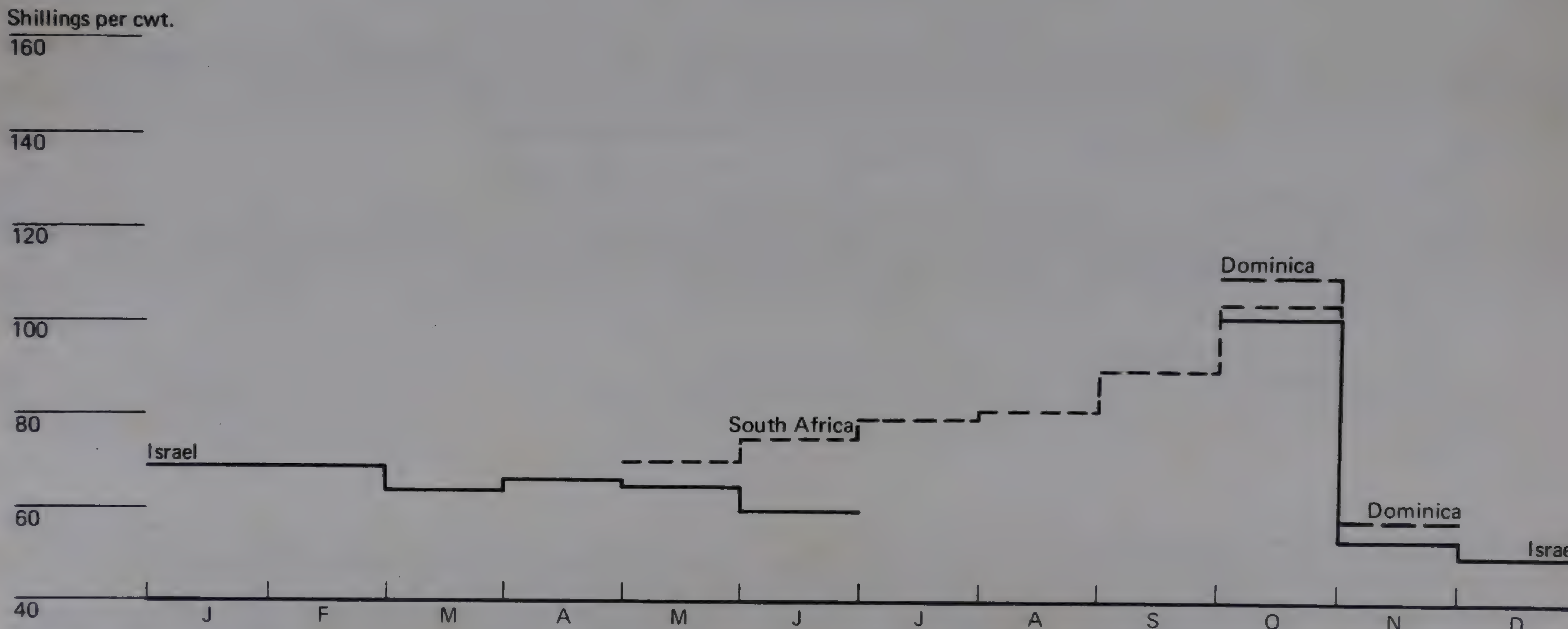
Grapefruit Monthly average prices at wholesale markets in England and Wales 1965



Source: Fruit Intelligence, Commonwealth Secretariat

Figure 11b

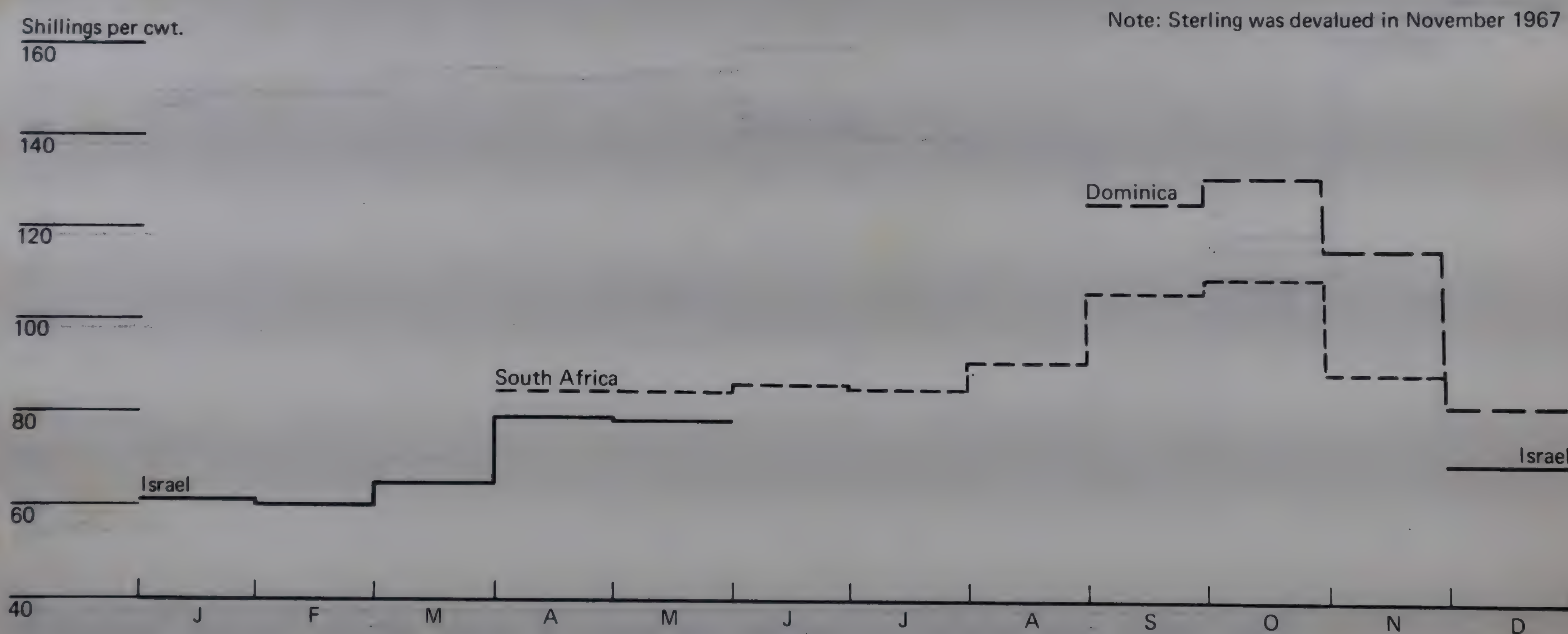
Grapefruit Monthly average prices at wholesale markets in England and Wales 1966



Source: Fruit Intelligence, Commonwealth Secretariat

Figure 11c

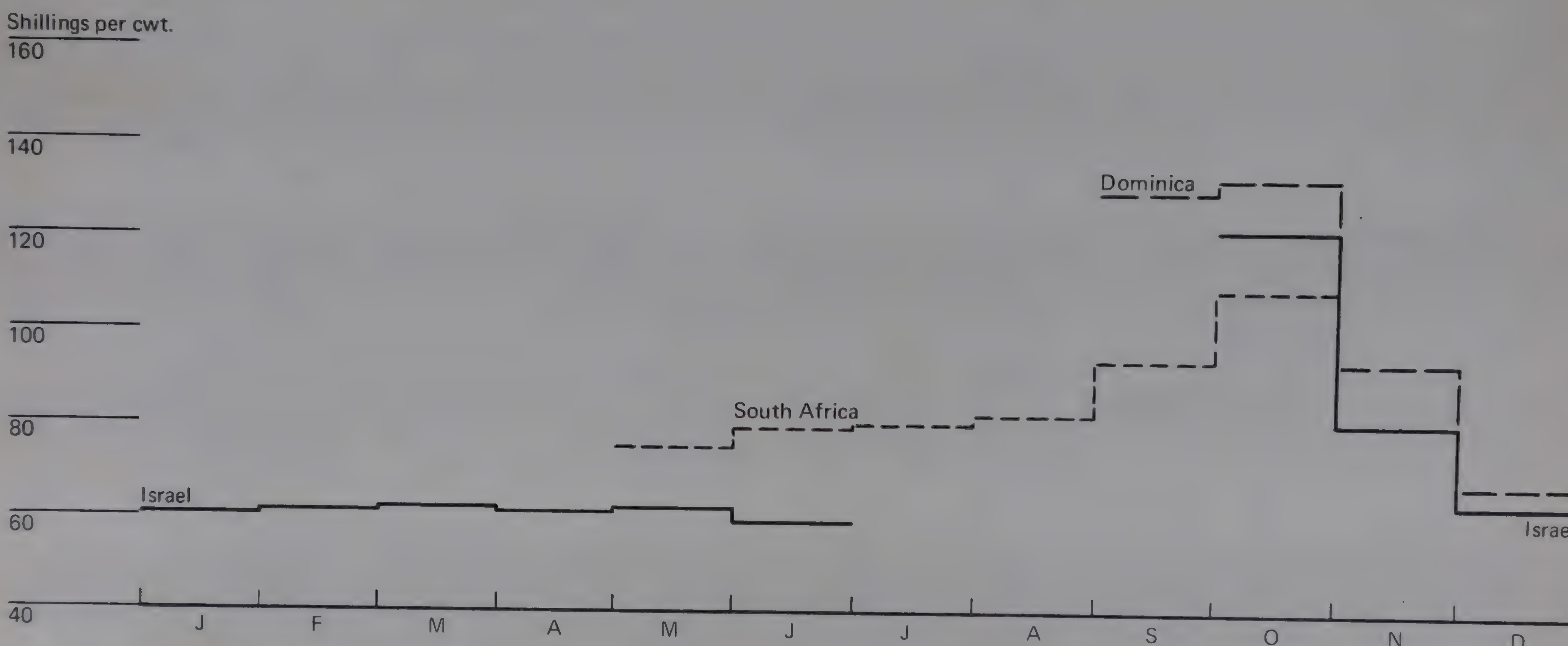
Grapefruit Monthly average prices at wholesale markets in England and Wales 1967



Source: Fruit Intelligence, Commonwealth Secretariat

Figure 11d

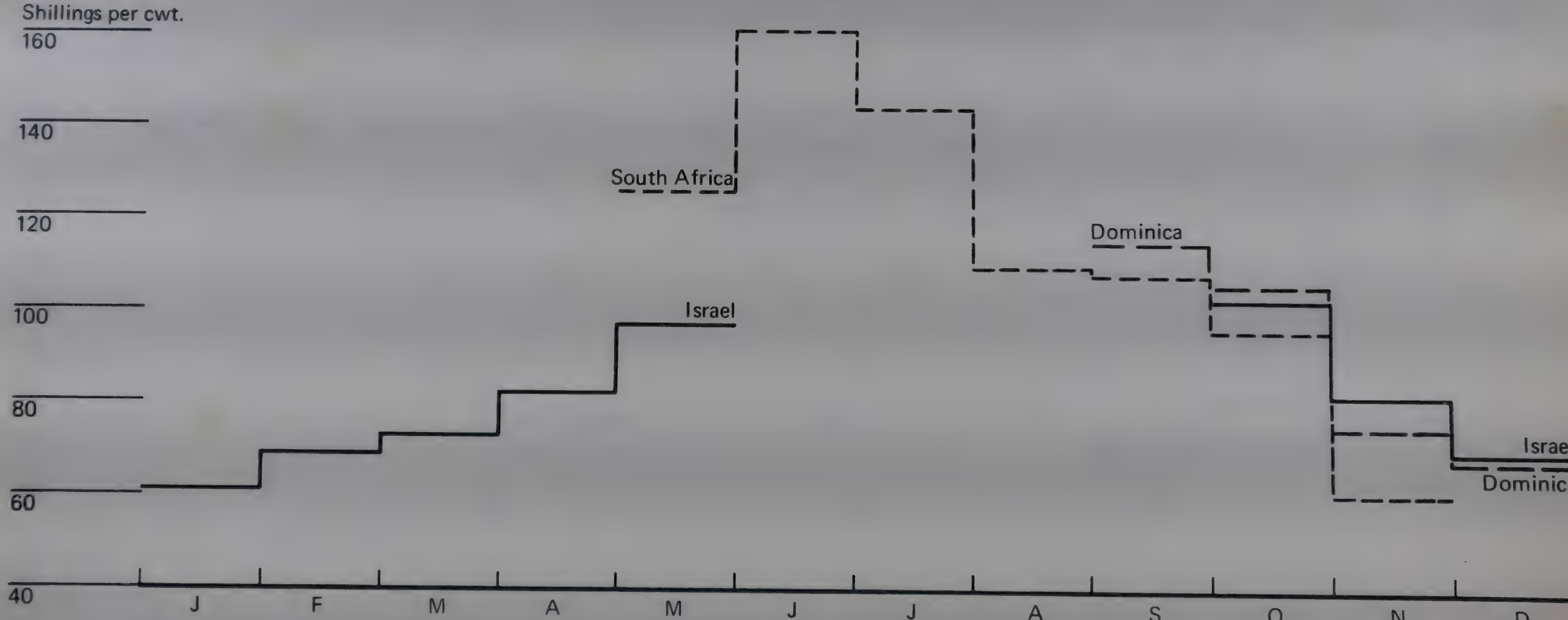
Grapefruit Monthly average prices at wholesale markets in England and Wales 1968



Source: Fruit Intelligence, Commonwealth Secretariat

Figure 11e

Grapefruit Monthly average prices at wholesale markets in England and Wales 1969



Source: Fruit Intelligence, Commonwealth Secretariat

fruit), prices then fall and may recover again towards the end of the season. However South African prices, though showing a premium over those paid for Israeli fruit in the early part of the season, generally rise to a peak at the end of the season. This is because, in recent years, substantial quantities of cold-stored Israeli grapefruit have been available until May or even June, whereas later in the season there is little or no competing fruit available until West Indian grapefruit begins to arrive in September. During the winter and spring months Israeli grapefruit fetches a premium at wholesale over that from Cyprus, Trinidad and other sources, thus maintaining the cif relationship noted above. This is attributed to its reputation for good quality.

Wholesale prices may be affected by many factors, chief of which are supply and demand. The price made by any particular consignment of fruit will also depend on its quality (in which the reputation of the exporter plays a large part) and the size of the fruit - the more popular sizes commonly fetch a premium over large or small fruit. Gluts of fruit are of less importance now, when desert-type grapefruit may be held in cold storage for up to two months, although knowledge that supplies are held in store may keep prices down. Another important factor is the previous trend of prices - after a period of short supplies and high prices demand is low, and even when more fruit becomes available retailers must dispose of their high-priced fruit before restocking with cheaper fruit, so prices may drop drastically before demand rises again (as happened in November 1966). This tends to happen in some degree every year after the high prices of the summer months and frequently even higher prices of September and October. The wholesale trade were of the opinion that more grapefruit could be sold, possibly at higher average prices, if fluctuations in supply could be ironed out.

Of course the wholesale trade does not present the complete picture of grapefruit sales since several of the largest chain stores obtain their supplies direct from importers or exporters' agents in this country (for example the CMBI and the Outspan organisation). The prices realised for direct sales are not known, although they are believed to be linked in some way to ruling wholesale market prices. Some chains are prepared to pay a premium over the wholesale price to obtain extra high quality fruit, while others buy at a fixed price over the season, or for part of the season. Thus, since chain stores do not pay the wholesalers' commission or market handling charges, it is possible that returns from direct sales exceed returns on similar fruit sold through the wholesale markets. On the whole, chain stores prefer to sell the best-known and widely advertised brands of grapefruit, namely Outspan in the summer and Jaffa in the winter months; minor suppliers are simply used to "fill-in" between the main seasons.

Retail prices for grapefruit may range from 7d to 1s 6d per piece and in independent retail outlets almost invariably follow the trend of wholesale prices. However chain stores frequently stabilise prices at a certain level over several weeks and sell different sized fruit, according to the wholesale price. There seems to be considerable consumer resistence to grapefruit priced at more than 1s 0d and high prices almost certainly encourage the use of canned grapefruit. Once customers begin buying canned grapefruit it may be difficult to wean them back to the fresh fruit.

The margins charged at different stages of the marketing process can obviously vary considerably. Importers'/wholesalers' commission will usually range from 8 to 10 per cent and a secondary wholesaler will also expect a margin of about this amount. Other costs incurred between importation and retail sale include dock dues, transport and market handling charges. The retail margin is the most variable component, depending on the custom of the individual retailer. On the whole, large chain stores and supermarkets having a quick turnover tend to charge a relatively small mark-up, whereas high-class fruiterers generally charge a relatively high mark-up. However, consumer resistence to high prices probably means that retail margins are smaller when wholesale prices are high. A typical mark-up in an independent retail outlet would be 40 to 50 per cent giving a 28 to 33 per cent profit margin.

The German Market for Grapefruit

Although grapefruit was virtually unknown in Germany before the War, consumption increased rapidly during the post-War years and per capita consumption doubled between 1963 and 1968, reaching 2.8 lb per head in the latter year. One importer forecast that imports might reach 150,000 tons per annum within the foreseeable future, which would make German per capita consumption the highest in Europe. On the other hand, another importer considered that the rate of increase of consumption would be lower in future.

There are only two major ports in Germany which handle fruit, namely Hamburg and Bremen. However, substantial supplies are received overland from Rotterdam, Marseilles and Trieste. Within the German railway system it is cheaper to transport goods from north to south than vice versa, which tends to encourage the use of the North German ports. There are primary wholesale markets in all the major centres of population, but the most important markets for citrus fruit are situated at Hamburg and Bremen. The Hamburg auctions are still of considerable, though declining, importance, for example in 1968/9, 20 to 25 per cent of Israeli grapefruit was sold through the Hamburg auctions, about 70 per cent of Cyprus fruit and 100 per cent of Honduras fruit (49).

The independent retailer is now of little importance in the urban areas of Germany, where fruit sales are chiefly effected through chain stores and supermarkets. The catering trade has never been an important outlet for fresh grapefruit, preferring to serve grapefruit juice. As in the United Kingdom grapefruit is eaten as a "starter" to a meal (but not usually at breakfast) and also as a dessert. It should be noted that the practice of eating fruit, such as melons, to start a meal, has only recently become established in Germany.

There is an increasing demand for pink-fleshed grapefruit (promoted by all exporting countries as "grapefruit rose") on the German market. Florida in particular, has promoted this type of grapefruit, as also has South Africa. Formerly, however, pink-fleshed grapefruit frequently had to be sold at a

discount, although prices were said to be equal to those for white-fleshed grapefruit last season. There also appears to be a growing demand for "tropical grapefruit" promoted as such, and sold in delicatessan stores. This was attributed by one importer to the promotion carried out by Florida and Honduras and their ability together to supply grapefruit on a regular basis virtually all year round. However, supplies of tropical grapefruit from other sources, such as Cuba and Trinidad, are regarded with some suspicion by wholesalers because of their short shelf life and liability to decay.

German buyers seem to prefer medium to small-sized grapefruit (counts 64 to 88 or 96 per 20 Kg box ie 48 to 66 per 15 Kg box). The larger sizes are preferred in South Germany where grapefruit is sold by the piece and the smaller sizes are sold in North Germany where retail sales of fruit are by weight.

Prices and Margins

The average cif values for imported grapefruit over the last six years are tabulated below:

	1963	1964	1965	1966	1967	1968
	Shillings and pence per cwt					
All sources	65/6	62/0	62/0	59/9	61/3	62/6
Israel	61/6	57/9	57/9	56/6	56/6	62/0
Cyprus	50/6	51/3	48/0	47/9	46/6	46/9
West Indies*	55/3	58/6	50/9	51/9	50/9	54/9
Honduras Republic	65/3	55/0	62/6	53/6	55/3	64/6
United States	77/3	73/6	67/9	66/3	68/0	74/0
Brazil	87/9	70/0	77/0	57/6	61/6	54/0
South Africa	77/3	80/0	77/3	76/0	85/6	75/6

* chiefly Trinidad

Source: Aussenhandel, Statistisches Bundesamt

Average values for grapefruit imported into Germany are somewhat lower than those for United Kingdom imports, both for "all sources" and for individual supplying countries (with the exception of South Africa). Moreover, there has been a decline in the overall average import value (calculated in marks rather than sterling). As in the United Kingdom, the highest average import prices are fetched by grapefruit sold in the summer months (from South Africa, the United States, and in the earlier years of the series, Brazil). Israeli fruit fetches a premium over that from Cyprus and Trinidad.

Unfortunately no series of wholesale or auction prices is available but "normal" prices for Israeli grapefruit are said to range from 20s 9d to 37s 6d per 20 Kg bruce box (ie 53s to 95s 6d per cwt) duty paid, ex quay and prices for South African fruit to range from 33s 6d to 41s 9d per 15 Kg carton (ie 113s 3d to 141s 6d per cwt) duty paid, ex quay (49). Obviously prices vary during the season according to supply and demand and the quality of the fruit. Large grapefruit generally make low prices per box.

Information concerning margins in the German fruit and vegetable trades is contained in the UNCTAD-GATT survey (50). The importer's margin ranges from 8 to 10 per cent. Auction brokers expect 2 per cent of the ex-quay price for goods sold on commission (this comes from the importer's margin) or 3 per cent of the invoice total for foods sold firm. Wholesalers' margins are generally between 10 and 15 per cent while retail margins range from 33 per cen in supermarkets to 67 per cent in some independent shops.

The French Market for Grapefruit

As in Germany, per capita consumption of grapefruit doubled between 1963 and 1968, in this case from 1.2 lb to 2.4 lb per head. However French importer do not expect consumption to increase so rapidly in future.

Marseilles and Le Havre are the major ports of entry for grapefruit imported into France but small quantities are also received overland from Spain and through the ports of Rotterdam and Trieste. There are primary wholesale markets in most large centres of population, the most important being at Rungis near Paris and Lyons in the South East. Since a large proportion of the French population lives in small towns or rural areas, distribution costs for imported fruit can be high. Auctions are not of any great importance in France, and many importers and more particularly, chain stores, buy firm on an fob basis. Last season (1968/9) more than 30 per cent of Israeli grapefruit imported into France was sold on a firm basis (51). Grapefruit from the United States is also usually bought on an fob basis.

The increase in consumption of grapefruit can probably be attributed to the promotion of this fruit in chain stores in recent years. Independent retailers are of minor importance as outlets, and the catering trade does not appear to be of any importance. Supermarkets frequently stock both tropical and desert types of grapefruit, charging slightly more for the former. It appears that there is a definite consumer demand for tropical grapefruit, although pink-fleshed grapefruit do not seem to be of much importance in France.

The sizes preferred on the French market are similar to those favoured in Germany ie counts 64 to 88 per 20 Kg box (48 to 66 per 15 Kg box). However tropical grapefruit rather larger in size is acceptable. Although by French law fruit should be sold by weight, in actual practice grapefruit is frequently sold by the piece or per bag of two or three fruit, especially in supermarkets

and chain stores. As a starter to a meal, grapefruit suffers severe competition from domestically produced melons during the summer months July to September. However in some circles, grapefruit is a "status" product.

Prices and Margins

The average cif values for imports of grapefruit into France during the last six years are shown below.

	1963	1964	1965	1966	1967	1968
	Shillings and pence per cwt					
All sources	65/0	63/0	61/3	67/3	73/0	75/6
Israel	54/6	53/9	52/9	59/6	66/9	69/9
Morocco	57/0	55/0	54/6	53/9	64/9	58/0
South Africa	80/4	75/9	81/3	83/3	77/9	75/0
Honduras	64/6	58/9	85/3	84/0	84/0	88/3
Surinam	83/6	99/0	107/9	101/0	103/3	139/0
United States	83/9	77/9	70/3	79/9	85/3	105/4

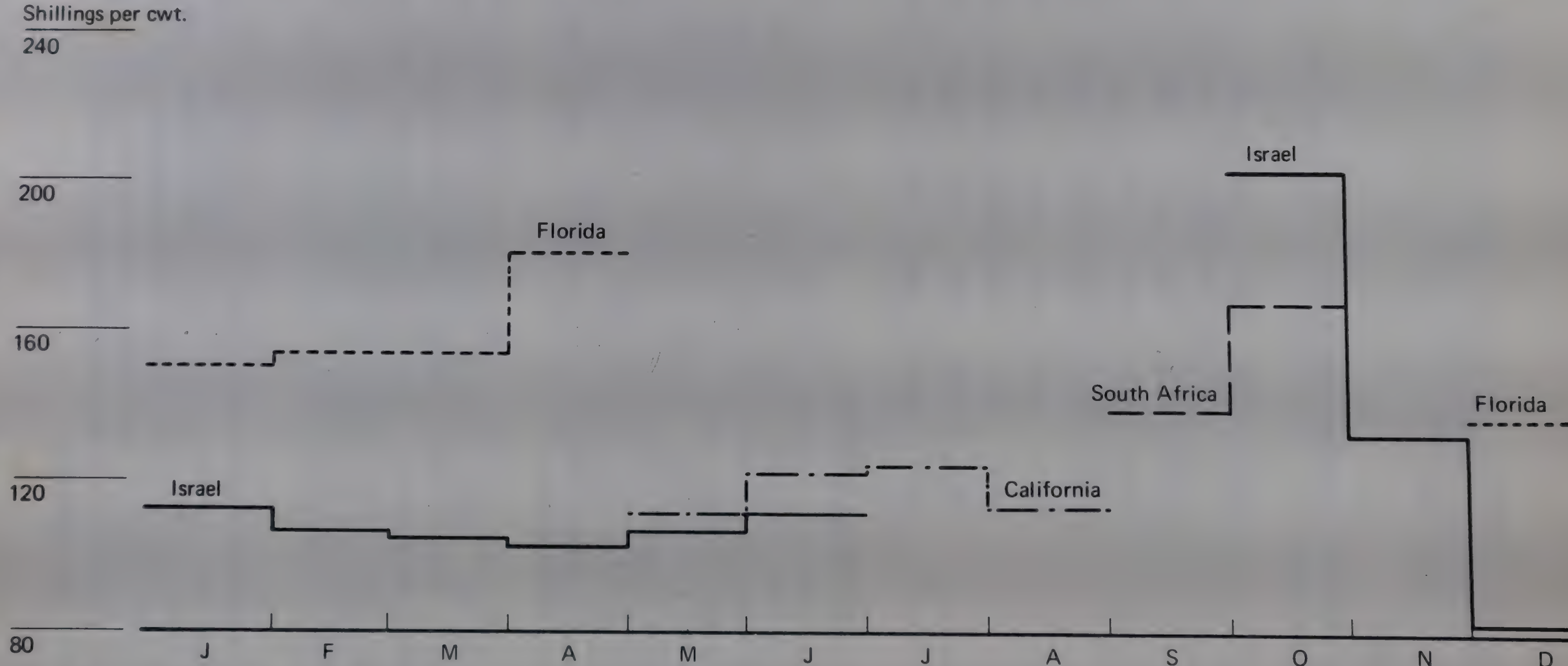
Source: Commerce Exterieur

The average value of French imports of grapefruit is relatively high, and exceeded the value of UK imports in 1966 and 1967 (the apparent rise in value in 1968 should be discounted since values actually fell in franc terms). These high levels are chiefly the consequence of obtaining a relatively large proportion of supplies from the United States - a high-cost producer, and also of the high prices paid for tropical grapefruit from Honduras and Surinam. It is interesting to note that prior to 1966 grapefruit from Morocco fetched a higher cif price than Israeli fruit - probably because the former colony enjoys duty-free entry for her grapefruit while Israel had to pay a relatively high rate of duty, which was reduced in 1966.

The average monthly prices paid for grapefruit on the Paris wholesale market during 1968 and 1969 are shown in fig. 12. Again a few supplying areas have been chosen (Israel, Florida, South Africa and California) to give some indication of seasonal fluctuations in prices. As in the United Kingdom prices reach their peak in October. The pattern of prices was atypical in 1969 when prices rose steadily from January to a peak in July. In more normal years prices are relatively low in July and August (when melons and other fruit are plentiful). The premium paid for tropical (Florida) grapefruit over desert-type grapefruit is evident.

Prices paid for grapefruit in provincial markets are generally somewhat higher than the prevailing level in Paris - some of this difference may of course be accounted for by costs of transportation. As mentioned above, direct sales of grapefruit to chain stores are of considerable importance in France, particularly in the Paris area, and this may mean that the Paris wholesale market is of less significance in the distribution of grapefruit than the London wholesale markets, for example.

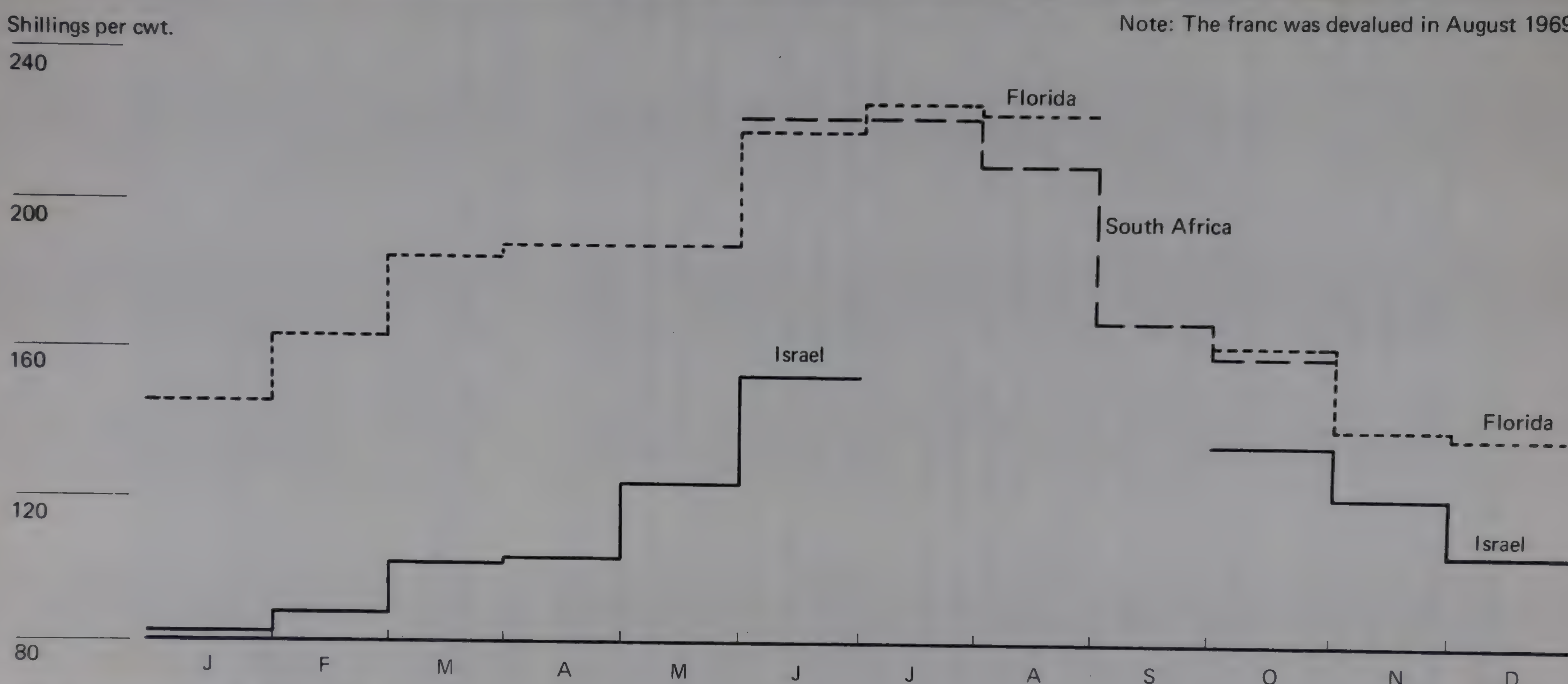
Figure 12a
Grapefruit Monthly average prices in the Paris wholesale market 1968



Source: Fruits d'Outre Mer, January issues

Figure 12 b

Grapefruit Monthly average prices in the Paris wholesale market 1969



Source: Fruits d'Outre Mer, January issues

The Netherlands Market for Grapefruit

Per capita consumption of grapefruit in the Netherlands also showed a rapid rate of increase over the period 1963 to 1968 - from 1.8 lb per capita to 3.4 lb (taking account of re-exports). The last two years, 1967 and 1968, showed particularly large increases in consumption (29 per cent and 26 per cent, respectively) but it seems unlikely that such a high rate of increase will be maintained.

Rotterdam is the largest port and fruit market in the Netherlands and also has an important entrepot trade with neighbouring countries. In Rotterdam and Amsterdam (the other large fruit market in the Netherlands) a very large proportion of imported fruit is sold by auction, although importers may sell direct to wholesalers or chain stores. The Rotterdam citrus auctions are attended by buyers from most Continental European countries, including the Eastern European countries.
Commission sales are the most usual method of trading, but "Extra" grade fruit may be bought firm on occasion. The major wholesale fruit markets are those in Rotterdam, Amsterdam, The Hague and Utrecht. Wholesalers buy their requirements at the auctions. Since the Netherlands is a very small, densely populated country, distribution costs are not high.

As in other European countries, grapefruit is eaten as a "starter" to a meal, and in this respect there is some competition from domestically produced melons during the months June to August. However, as in other continental European countries there is virtually no competition from canned grapefruit segments on this market. So far as the quality and type of fruit is concerned, Dutch consumers appear to prefer small grapefruit (counts of up to 100 per 20 Kg box, or 75 per 15 Kg box) - it has been suggested that this may be becaus[e] fruit is sold by weight at the retail level. However, there seems to be little prejudice against tropical grapefruit from the United States, Surinam and Honduras, although tropical fruit tend to be rather large. One major chain of supermarkets has relied chiefly on Surinam grapefruit (bought direct) during recent seasons.

Prices and Margins

The average cif values for grapefruit imported into the Netherlands over the last six years are shown overleaf.

	1963	1964	1965	1966	1967	1968
	Shillings and pence per cwt					
All sources	50/3	49/0	50/9	53/0	61/0	52/6
Israel	55/9	45/3	45/3	53/3	55/6	52/0
United States	57/0	60/6	61/6	60/6	73/3	52/9
Surinam	46/9	43/6	49/9	53/0	56/0	56/6
Honduras	42/9	32/0	47/0	36/0	52/9	49/9
Brazil	57/0	25/9	34/0	24/6	50/9	38/0
Paraguay	-	-	60/9	36/0	61/3	38/3
South Africa	48/0	53/6	51/3	75/9	66/6	49/3

Source: <u>Maandstatistick van de In-Uit -Voer</u>

The average value of imports of grapefruit is generally low compared with that in other markets studied but it showed an upward trend until 1967, before falling in 1968 (the fall was of course, larger in terms of guilders). However the trends for the individual supplying countries varied considerably, only Surinam showing a steady upward trend in values from 1964 to 1967. It has been suggested that the auction system is responsible for the fluctuations in prices both within a season and between one season and another and is disliked by some exporters. The general fall in prices in 1968 suggests that the market was over-supplied in that year and that demand was not so bouyant as the rise in per capita consumption might imply.

Unfortunately the auction system of sales does not permit the compilation of average wholesale prices for markets in the Netherlands. Importers charge a rate of between 6 and 8 per cent commission, but the average gross margin on firm sales is of the order of 10 per cent. Wholesalers expect a gross margin of 10 to 15 per cent. Retail prices are low relative to those in some other European countries, the retail margin being estimated at about 25 per cent (52).

The Belgian Market for Grapefruit

Belgium was an important market for grapefruit in the pre-War years, but per capita consumption has not risen as rapidly in Belgium as in the other EEC countries in recent years. Nevertheless in 1968 per capita consumption averaged 2.8 lb - a 75 per cent increase over the 1963 figure.

The main port in Belgium is Antwerp, where citrus is also auctioned. As in the Netherlands, most citrus fruit imported into the country is sold through the auctions, although chain stores may import direct. There are wholesale markets in all the large centres of population, the most important being that in Brussels. Distribution costs are low since the country is small and densely populated. Chain stores are probably of less importance as outlets for fruit and vegetables in Belgium than in the Netherlands and Germany, for example,

although large department stores generally sell fruit and vegetables.

There appears to be no particular preference for desert-type as against tropical grapefruit. Medium to small fruit are required on this market.

Prices and Margins

Average cif values for grapefruit imported into Belgium during the last six years are shown below.

	1963	1964	1965	1966	1967	1968
		Shillings and pence per cwt				
All sources	52/6	51/0	51/3	53/9	57/9	59/9
Israel	48/0	49/3	47/9	51/6	52/0	59/6
United States	57/0	53/9	58/9	59/0	70/0	-
South Africa	60/3	-	-	-	-	-

Source: Commerce Exterieur

These average values are somewhat lower than those for German and French imports, but similar to Dutch import values. There was a rising trend in average values (in sterling terms) from 1964 to 1968 while values of imports from the United States also rose. The upward trend in value of Israeli grapefruit was interrupted by a decline in 1965. It should be noted that United States grapefruit invariably fetched a premium over Israeli fruit, while in 1963, the only year for which information is available, South African supplies fetched a higher average price than American.

Unfortunately no wholesale prices are available for grapefruit sold on Belgian markets. However a study made in 1964 (53) estimated that gross wholesale margins are between 10 and 16 per cent while the retailer's margin varies between 65 and 110 per cent. In addition a transmission tax of 14 per cent is levied on the gross landed value of the fruit (cif value plus any import duty payable). Therefore retail prices in Belgium are relatively high and probably serve to limit consumption.

The Swiss Market for Grapefruit

In recent years per capita consumption of grapefruit in Switzerland has on occasion exceeded that in the United Kingdom. Consumption has fluctuated somewhat, but rose from 2.7 lb per head in 1963 to 3.6 lb in 1967 before falling to 3.3 lb in 1968.

As Switzerland is a completely land-locked country all imports are received by rail or road from Rotterdam and various South European ports. The only established wholesale market as such, is in Geneva; in other major cities - Basle, Zurich, Lausanne and Lucerne, fruit and vegetables are sold directly from rail wagons, the importers' premises being situated close to the railway sidings. There is one large co-operative retail group - "Migros" - which imports on its own account and employs a buyer in Milan wholesale market. Migros accounts for a substantial proportion of retail fruit and vegetable sales in Switzerland, but may not be a major outlet for grapefruit. Migros of course buys on a firm basis, as do most of the importers.

Pink and red-fleshed grapefruit are accepted on the Swiss market, but most grapefruit sold is of the white-fleshed desert type. Medium to large fruit are preferred - counts 48 to 64 per 20 Kg box (36 to 48 per 15 Kg box). There is said to be an increasing preference for the larger sizes.

As a starter to a meal, grapefruit suffers competition from melons during the summer months (per capita consumption of melons is relatively high in Switzerland) and also from fruit juices throughout the year. Canned grapefruit is of little or no importance except possibly in catering outlets. It seems likely that there is a substantial catering demand for grapefruit in Switzerland resulting from the large number of tourists staying in the country, especially during the winter months. This would account for the apparently high level of per capita consumption.

Prices and Margins

The average cif values for grapefruit imported into Switzerland during the last six years are shown below:-

	1963	1964	1965	1966	1967	1968
		Shillings and pence per cwt				
All sources	65/6	64/3	69/6	67/6	68/3	71/0
Israel	58/3	59/0	60/0	62/6	60/0	69/6
Cyprus	-	-	76/0	56/9	59/6	57/6
United States	101/0	86/9	98/6	83/3	89/6	101/6
South Africa	94/9	85/3	104/0	93/3	102/3	91/0

Source: Statistique de la Suisse

The level of import values is similar to that for United Kingdom imports and rather higher than those for some other continental European countries, probably because of additional transport costs. There is no obvious trend in import values - the average value was highest in 1965 (the 1968 average value was lower than that of 1967 in franc terms). As would be expected, Israeli grapefruit fetches lower prices than that from the United States and South Africa, but generally fetches a premium over Cyprus grapefruit. The prices paid for US and South African fruit are unusually high, but this may be accounte for by high transport costs from North European ports.

Unfortunately there is no information available concerning wholesale prices on Swiss markets, or importers' and wholesalers' margins. Migros, however, operates on a two per cent profit margin, ie 8 to 10 per cent gross margin, which presumably means that fruit prices are low in their stores.

The Italian Market for Grapefruit

Although small quantities of grapefruit are produced in Italy this fruit was virtually unknown before import regulations were liberalised in 1964, and even now consumption is limited to large urban centres. Per capita consumptic is still very low, having increased from 0.04 lb per head in 1963 to about 0.3 lb per head in 1968. This obviously leaves much scope for an increase in consumption, although, as Italy is a major producing country of other types of citrus, grapefruit consumption may not rise to the levels prevailing in other European countries. It is quite possible that the main consumers of grapefruit are tourists and foreign residents in Italy.

Trieste is one of the ports utilised by the Israeli Board to supply Northern European countries and most Italian imports of grapefruit presumably pass through this port. Supplies may also be received overland from Marseilles. The main wholesale markets are situated in the large urban centres of Northern Italy, the most important market for imported fruit being at Milan, which handled more than 30 per cent of the grapefruit imported in 1968 (54). Buying on a firm basis is the general rule - virtually all Israeli fruit is bought firm.

Although chain stores and supermarkets have increased their share of the retail food trade very rapidly in recent years, especially in Northern Italy, fruit and vegetables are still sold chiefly through small independent retail outlets and street traders.

Since imports were liberalised, virtually all grapefruit imported have been of the desert-type which may be assumed to be the preferred type on this market.

Prices and Margins

Annual average cif values of grapefruit imported into Italy over the period 1963 to 1967 are shown below:-

	1963	1964	1965	1966	1967	1968
		Shillings and pence per cwt				
All sources	51/0	64/0	63/0	68/0	72/3	66/6
Israel	-	65/0	60/6	69/0	66/0	66/0
Somalia	53/6	45/6	63/0	46/9	49/7	...
South Africa	-	-	-	81/3	90/6	...

Source: Comercio con L'Estero

Import values showed a rising trend until 1967 as first Israeli and then South African grapefruit was introduced to the Italian market. Except in 1965 the value of imports from Somalia was well below that of Israeli supplies. South African grapefruit fetched very high prices in 1966 and 1967.

Unfortunately no wholesale price series is available for grapefruit sold on Italian markets - since this fruit is of minor importance, price quotations tend to be sporadic. Prices at Milan market during 1968 varied from about 150s 0d per cwt during the early months of the year to 126s 6d during the later months (presumably for Israeli grapefruit) (55). These wholesale prices are high, in comparison with wholesale prices in other countries, which suggests that demand was not fully met. These prices were also more than double import values for 1968 - which illustrates the tendency for wholesale margins to be rather high in Italy.

The Scandinavian Markets for Grapefruit

Per capita consumption of fresh grapefruit is lower than the European average in all the Scandinavian countries (1.2 lb per head on average in 1967). However consumption of grapefruit juice is high, particularly in Sweden (56), and this probably limits the fresh fruit market.

Although wholesale markets exist in the main centres of population, co-operative retail groups are the major outlets for fruit and vegetables in Scandinavia and these organisations import on their own account. Firm buying is the rule, although auctions are still held in Copenhagen (Denmark).

Pink-fleshed grapefruit is said to be popular in Scandinavia, especially in Sweden, and Florida and Texas fruit generally fetches a premium (57).

If import values are taken as an indication of wholesale prices, the level of prices in Denmark and Finland is similar to that in the United Kingdom but prices in Sweden and, more particularly, Norway, are the highest in Europe. These high prices are of course, partly accounted for by the distance of the Scandinavian countries from their suppliers.

The existence of value-added taxes in these countries at rates varying from 11.11 per cent to 12.5 per cent serves to raise retail prices, but since these taxes are levied on all goods, consumption of grapefruit relative to other fruits should not be affected.

PART IV: CONCLUSIONS AND FUTURE PROSPECTS FOR THE FRESH GRAPEFRUIT MARKET

The first three sections of this report described the production, trade and markets for fresh grapefruit at the present time. This final section attempts to project future trends in production and consumption and hence estimate market prospects for potential suppliers of fresh grapefruit to world markets. The subject is considered initially on the basis of past trends and secondly on a more conjectural basis.

Production

FAO estimates of future grapefruit production suggest that it could reach 3,560,000 tons by 1975 (1). This is a figure of output potential, taking account of bearing acreage, new plantings, and possible increases in yield, but ignoring the possible effects of adverse weather conditions. The FAO estimates of production in major producing countries for 1975 are as follows:-

	Long Tons
United States	2,460,000
Israel	315,000
South Africa	123,000
Argentina	98,000
Cyprus	44,000
Caribbean Area	157,000
	3,197,000

Source: Review of 1975 Projections for Citrus Fruit CCP: CI 69/5 Add 1. FAO

However in the United States and Argentina a large proportion of the crop will be required for local consumption and for processing into segments or juice. Potential export availabilities for grapefruit in the major producing countries in 1975 are therefore estimated by FAO as shown below:-

	Long Tons
United States	638,000
Israel	270,000
South Africa	98,000
Argentina	6,000
Cyprus	39,000
Caribbean Area	90,000
	1,141,000

Source: Review of 1975 Projections for Citrus Fruit. FAO

FAO estimates that by 1975 240,000 tons of this total will be required for processed products entering international trade, leaving some 900,000 tons to be absorbed by the fresh fruit trade. However, since domestic disappearan of the US grapefruit crop in 1966/7 exceeded that forecast by the FAO for 1975, the figure for US export availabilities is almost certainly an over-estimate. In fact total export availability will probably be less than 600,000 tons.

Consumption

a. Past Trends

Estimates for 1975 consumption of grapefruit in the major importing countries have been prepared by FAO based on average imports during the period 1963/4 to 1966/7, estimated population growth and income increases. Import data for more recent years, however, suggest that these estimates should be revised, so projections for 1975 based on imports up to and including 1968 have been prepared in TPI. The two sets of estimates are shown below:-

Long Tons

Importing Country	1968 Per Caput consumption in lb	1968 Net Imports/ Total Consumption	FAO estimates for 1975 Per caput consumption in lb	FAO estimates for 1975 Total consumption	TPI estimates for 197 Per caput consumption in lb.	TPI estimates for 197 Total Consumptio
United Kingdom	3.6	89,630	4.0	101,000	3.9	99,200
Canada	7.4	68,497	8.1	86,000	9.1	94,800
Germany	2.8	71,692	2.6	74,000	3.8	106,900
France	2.4	52,587	2.6	62,000	3.9	91,900
Netherlands	3.4	19,131	3.1	19,000	3.9	23,900
Belgium	2.5	10,916	3.1	14,000	3.7	17,400
Italy	0.3	6,997	0.7	16,000	1.3	31,600
Switzerland	3.3	8,976	3.7	11,000	3.6	10,800
Sweden	1.1	4,038	1.8	7,000	1.7	6,500
Denmark	1.7	3,295	2.0	5,000	1.8	4,100
Finland	1.1	2,325	1.5	4,000	1.6	3,500
Norway	0.8	1,309	1.8	3,000	1.0	1,800
TOTALS				402,000		492,400

Sources: Review of 1975 Projections for Citrus Fruit: Statistical Supplement and see Appendix E.

A linear projection of past import trends would not provide a satisfactory estimate of future consumption because of the trends in grapefruit consumption in many continental European countries. Consumption was at a very low level until the early nineteen-sixties, but has risen rapidly latterly; however, this rate of increase is unlikely to be sustained and would be expected to slacken. The FAO projections are based on estimates of future income growth and the estimated income-elasticity of demand for grapefruit (expected to decline over time), assuming that prices remain constant at the levels of the base period (1963/64 to 1965/66 average). The method used for the TPI projections is explained in Appendix E. After correction for price movements, data for grapefruit consumption per caput over the period 1960 to 1968 were fitted to a sigmoid curve, which was then projected to 1975 in the same manner as a straight-line projection. In this case prices were assumed to remain constant at the average level over the period 1960 to 1968.

In total the TPI projections are considerably higher than the FAO projections, as a result of much higher estimates for imports into Canada and the EEC countries. On the other hand FAO estimates are marginally higher for the United Kingdom, Switzerland, and the Scandinavian countries. Any projection of Italian consumption is bound to be a "guessestimate" since consumption was negligible until very recently. It is interesting to note that the TPI projections put per caput consumption in 1975 at approximately 3.8 lb per annum in all the major European importing countries, apart from Italy.

Thus, if the TPI estimates for consumption in 1975 are reached; the export availability of grapefruit will exceed import demand by approximately 100,000 tons. However several factors may help to ameliorate the situation.

In the first place, past experience suggests that the United States crop will suffer periodic frost damage which will reduce the actual production figure to an appreciable extent, compared with potential production estimates. It will be remembered that increased production in the United States will contribute a large part of the projected surplus.

Secondly, large crops and the resulting low prices may stimulate domestic demand in the United States, and thus reduce export availability, by a greater extent than allowed for in the FAO projections.

Thirdly, no account has been taken of the possible emergence of the East European countries as regular purchasers of grapefruit (as they already are of other citrus fruits). These countries constitute a very large potential market, but at present import only about 5,000 tons per year on an occasional basis.

Finally, it seems possible that import demand is under-supplied during the months July to October at the present time and considerable quantities of fresh grapefruit could be absorbed during these months if they were available. This aspect will now be examined more fully.

b. Seasonal Demand

Up to this point all calculations concerning consumption have been made on an annual basis. However as was shown in Part II of this report, the average level of imports during the months July to October is generally much lower than during the other months of the year. Thus consumption of grapefruit is highest during the winter and spring months, rather than during the summe and autumn months when warm weather might be expected to stimulate deman It seems likely that although demand will continue to increase during the winte months (especially in Italy), there is more scope for increasing consumption during the months July to October, and in particular during September and the first two weeks of October.

Is this a reasonable hypothesis? Wholesale prices in the United Kingdom, an to a lesser extent in France are high in the summer and autumn months comp with the rest of the year, which suggests that larger quantities of grapefruit could be sold at this time, if they were available. This opinion is certainly held by members of the trade in the United Kingdom (see page 67).

One factor which may hitherto have curbed demand for grapefruit during the summer and autumn months is the quality of the fruit generally available at this time. The leading suppliers from July to September are South Africa, ar to a lesser extent, Brazil. Grapefruit from these countries takes twice as long to reach the European consumer as Mediterranean fruit and is generally accepted to be of lower intrinsic quality. By September and October virtually all South African grapefruit on the markets has been held in cold storage. Th first shipments of the new season's crop from Mediterranean countries, which arrive towards the end of October, sometimes contain immature fruit. Although grapefruit from the Caribbean, generally considered to be of excellent eating quality, becomes available in September, only limited quantities are exported, chiefly to the United Kingdom. In North America, Californian summer grapefruit is held on the tree by use of hormone sprays, rather than held in cold storage, but there is a problem with immature early shipments of Florida fruit.

On the other hand it is possible that demand for grapefruit is low during the months July to October. There are several factors which might adversely affect demand at this time, for example domestically produced fruits are at their cheapest and most plentiful in the Northern Hemisphere during these months. In particular melons (which compete directly with grapefruit as a starter to a meal) are readily available. July to September are also the main holiday months in Europe and North America, although some members of the fruit trade in the United Kingdom consider that this stimulates catering deman for fresh grapefruit.

Taking these various factors into account, it is possible to estimate the prese unsatisfied demand for fresh grapefruit during the months July to October as follows:-

Long Tons

	July	August	September	October*	Total for this period
TOTALS of which	4,500	6,000	11,000	3,500 + (a)	25,000
United Kingdom	1,000	2,500	4,500	1,500	9,500
Germany	1,000	750	1,500	1,000	4,250
France	1,000	1,000	2,500	750	5,250
Canada	1,000	1,000	1,500	(a)	3,500 + (a)

* 1st 2 weeks (a) from 0-2,000 tons depending on US crop

These estimates are rough orders of magnitude only, based on the difference between imports during these months and the monthly average over the year for 1966, 1967 and 1968. The estimates are based on the assumption that latent demand for grapefruit is at a lower level during the summer and autumn than during the rest of the year, except in the United Kingdom, where it is assumed that latent demand is at a similar level all year. On this fairly conservative basis demand during these four months of the year is at present under-supplied by some 25,000 tons. However, if one assumes that the level of demand for fresh grapefruit is much the same all year round and only slightly affected by the availability of competing fruit from July to October, it may be reckoned that Western Europe and Canada could absorb in excess of 50,000 tons more grapefruit during the period July to October, unsatisfied demand being especially high in September. These estimates do not take account of any future increases in population or in the basic level of demand.

These estimates of 25,000 to 50,000 tons unsatisfied demand during the period July to October do not take account of potential demand in the United States since monthly supply data is not available for this market. However it seems likely that the United States could absorb as much grapefruit again as Western Europe and Canada during the months June to September (rather than July to October) if the gap in domestic supplies were to be filled by imports, although there is no evidence of this happening, as yet. This is possibly because the United States has very strict phyto-sanitary regulations for imported citrus fruits.

Prospects for a New Entrant to the Trade in fresh Grapefruit

To sum up the conclusions of this report:-

The major import markets at the present time are the United Kingdom, Canada, Germany and France and it is in these countries and Italy that increases in consumption are expected to be greatest in future. However any increase in demand during the months November to June can be met by the large increase in supplies expected in the established exporting countries - Israel, the United

States and Cyprus. Nevertheless there seems to be a considerable measure of unsatisfied demand for fresh grapefruit during the months July to October, when South Africa is the only large scale supplier to world markets. (Much of the projected increase in South African supplies will be available in May a June). In particular there is a "supply gap" during September and the first two weeks of October when supplies at present are limited to cold-stored South African fruit and small quantities of grapefruit from the Caribbean. In addition to the unsatisfied demand in Europe and Canada, it is possible that the United States market could offer a further outlet from June to Septem or early October.

To meet the requirements of consumers in Europe and North America a potential supplying country would have to offer good quality, seedless grapefr having a yellow skin colour, thin skin, good internal quality and a reasonably long shelf life. White-fleshed grapefruit is usually preferred in European markets, but pink-fleshed fruit is acceptable in Germany and Scandinavia and preferred in North America. Desert-type grapefruit meet the requirements of the European trade rather better than tropical grapefruit. However a distinct but small demand for tropical grapefruit has developed in France and Germany and most grapefruit sold on North American markets are tropical-type fruit. In order to supply good quality grapefruit to North American and European markets during the summer months, refrigerated shipping would be necessary, but by September and October it might be possible to use ventilate stowage. To become established on European markets a new supplier would have to be able to supply grapefruit regularly and not export on an occasional basis.

Grapefruit of course has to comply with the phyto-sanitary and chemical resid regulations of the importing countries. These are restrictive only in the United States and Italy, and, in the latter case, exporting countries may apply for a waiver.

At present wholesale prices in the United Kingdom and France (the only two countries for which figures were available) are high during the summer month and reach a peak in September or October. Increased supplies would be expected to exert a downward influence on prices, but the precise effect is impossible to estimate.

This assessment of a potential supplier's market prospects for fresh grapefru might be affected by unforeseen factors. For example, the problems of cold storage of grapefruit over long periods might be overcome so that Israeli and even Florida grapefruit could be available on European markets in July or eve later, while South African grapefruit supplies could be increased in Septembe and early October. However storage inevitably increases the cost of these supplies.

Developments which might affect the future market for grapefruit as a whole in the more distant future (after 1975) include the possibility that production of grapefruit could be established in the EEC - presumably in Italy. This would probably be followed by the introduction of reference prices on EEC markets, possibly higher tariff barriers, and the virtual closure of the Italian market to other suppliers, at least during the Mediterranean season, as has already happened for other citrus fruits.

REFERENCES

1. Review of 1975 Projections for Citrus Fruit, FAO, CCP: CI 69/5, p.8.

2. The Citrus Industry, Vol. 1, ed. W. Reuther et al, University of California, Berkeley, 1967, pp. 541-2.

3. Ibid. p. 542

4. Ibid. p. 543

5. Ibid. p. 545

6. Ibid. p. 544

7. Ibid. pp. 549-50

8. Ibid. p. 540

9. Citrus Fruits by States, Statistical Bulletin No. 296, United States Department of Agriculture, 1961. p. 2

10. Review of 1975 Projections for Citrus Fruit, FAO, 1969, p. 8

11. Florida Agricultural Statistics: Citrus Summary 1968, Florida Departmen of Agriculture, p. 33

12. Ibid. p. 20

13. Ibid. p. 21

14. Review of 1975 Projections for Citrus Fruit, FAO, 1969, p.8

15. Fruit: a Review, No. 16, Commonwealth Secretariat, London 1967, p.93

16. "Israel Grapefruit Planting Frozen", Citrus Industry, 1963, 44, (6), p.30

17. Review of 1975 Projections for Citrus Fruit, Statistical Supplement, FAO, 1969, p.44

18. Ibid. p. 12

19. "Preview: South Africa's Farm Trade" by R.E. Kampe, Foreign Agriculture, 1968, 6, (39), p.5

20. Fruit Intelligence, 1965, XV, (2), p. 18

21. Fruit Intelligence, 1969, XIX, (10), pp 674-5

22. "Argentine Fresh Fruit Exports", International Fruit World, 1969, XXVIII, (3), p. 36

23. "Cyprus Forges Ahead with Citrus Build-up", Fruit Trades Journal, 1969, 135, (7), p.42

24. Fruit: a Review, No. 16, Commonwealth Secretariat, 1967, p.93

25. Fruit Intelligence, 1969, XIX, (1), p. 23

26. Annual Report of the British Honduras Department of Agriculture, 1962, p. 2.

27. The Citrus Industry, ed. W. Reuther et al, Vol 1, p. 168

28. Ibid. p.171

29. "Italian News", Fruit Trades' Journal, 1969, 136, (35), p. 20

30. Fruit Intelligence, 1969, XIX, (11), p.727

31. "Growers Concentrate on Fewer Export Varieties", Fruit Trades' Journal, 1969, 136, (45), Supplement p. 9

32. "The Foundations for Future Production and Export of West Indian Citrus", by D. McFarlane, Social & Economic Studies, 1964, 13, (1) p.137

33. Albert Heijn N.V. Private Communication

34. "The Foundations for Future Production and Export of West Indian Citrus", by D. McFarlane, Social & Economic Studies, 1964, 13, (1) p.137

35. Fruit: A Review, 1957, Commonwealth Economic Committee, 1958, p.77

36. Lead Arsenate for Earlier Grapefruit Harvesting by I. Hosein, Citrus Research Bulletin No. 13, University of the West Indies, Trinidad, 1969, p. 2.

37. Proceedings of the Florida Horticultural Society, 1966, 79, pp 258-64

38. Factors Affecting the Quality of Grapefruit Exported from Florida, Marketing Research Report No. 739, U.S. Department of Agriculture, 1966

39. "Texas Round-up", Citrus & Vegetable Magazine, 1965, 28, (7), p.37 and (11) p. 24

40. Competitive Practices in Marketing Florida and Texas Fresh Grapefruit, Marketing Research Report No. 629, U.S. Department of Agriculture, 1963.

41. Florida Agricultural Statistics, Citrus Summary 1968, Florida Departme
of Agriculture p. 37

42. Ibid. p. 41

43. Ibid. p. 21

44. Ibid. pp20, 21, 26-8 & 44

45. Ibid. pp 26-7

46. Ibid. pp 27-8

47. Ibid pp 27 & 41

48. Ibid. p. 37

49. Afrikanische Frucht-Compagnie Laeisz & Co. Private Communication

50. The Fresh Fruit and Vegetable Market in Seven European Countries, Vol. 1, UNCTAD-GATT, Geneva, 1968, pp 137-8

51. Citrus Marketing Board of Israel. Private Communication.

52. The Fresh Fruit and Vegetable Market in Seven European Countries, UNCTAD-GATT, Vol. 1, p. 237

53. "La formation des prix des fruits, legumes et produits laitiers" by P. Bairoch & G. Thorn, Institut de Sociologie, ULB, Brussels, 1964.

54. Ortomercato Riepilogo Annuale, Milan, 1968 p. 58

55. Bollettino dei prezzi del giorno, Ortomercato Milan.

56. Moller & Co. A.B. Private Communication.

57. The Fresh Fruit and Vegetable Market in Seven European Countries, UNCTAD-GATT, Vol. 1, p. 368.

REVISED EUROPEAN STANDARD FOR GRAPEFRUIT

moving in trade between European countries.

I. Minimum Requirements

1. Without prejudice to stricter international and national requirements concerning phyto-sanitary measures and the use of chemicals, the fruit must be:

- intact
- sound (subject to the special provisions for each class)
- free from damage or deterioration caused by frost
- clean and free of all visible traces of chemicals
- free of all abnormal external moisture
- free of foreign taste or smell

2. The fruit must have been carefully picked and have reached an appropriate degree of development and ripeness in accordance with criteria proper to the variety and to the area in which they are grown. The state of ripeness must be such as to allow the fruit to withstand transport and handling and to meet market requirements at the place of destination.

Furthermore, the degree of colouring shall be such that, following normal development, the fruit reach their normal variety colour (special conditions applicable to each class) at their destination point, account being taken of the time of picking, the growing area and the duration of transport.

Fruit meeting these ripeness requirements may be "degreened". This treatment is permitted only if the other natural organoleptic characteristics are not modified. It shall be carried out in the manner prescribed by the administrative authorities in each country and under their supervision.

3. The fruit must be free from signs of shrivelling and bruising and from extensive healed-over cuts.

II. Minimum Juice Content and Colouring

- this refers to juice content in comparison with the total weight of the fruit, extracted by means of a hand press.

  Minimum juice content = 35 per cent.

Colouring must be normal for the varietal type. However, fruit with a greenish colour are allowed if they meet with the minimum requirements of juice content, account being taken of the time of picking and of the growing area.

III. Classification

i. "Extra" Class - fruit in this class must be of superior quality, free from any blemishes affecting their external appearance and/or their organoleptic characteristics. However, very slight superficial alteratio of the skin are not considered as "defects". Furthermore, fruit must show the characteristics and especially the typical colouring of their variety, account being taken of the time of picking and of the growing are

Tolerances - 5 per cent by number or weight of fruit not satisfying the requirements of the class, but conforming to those of Class I and not more than 5 per cent by number of the fruit having lost their button.

ii. Class I - fruit in this class must be of good quality. They must display characteristics typical of the variety or type, having regard to the time of picking and to the area in which they are grown. The following defects however, are allowed, provided they do not impair the general appearing or keeping qualities of fruit of a given consignment:

- slight defect in shape
- slight defect in colouring
- slight skin defects inherent in the formation of the fruit, such as silver scurfs, russets, etc.
- slight healed defects due to accidents

Tolerances - 10 per cent by number or weight of fruit not satisfying the requirements for the class, but conforming to those of Class II, and not more than 20 per cent by number of fruit having lost their button.

iii. Class II - this class comprises fruit which as a whole does not qualify for inclusion in the higher classes but satisfies the minimum requiremen specified above. Defects or changes in appearance and skin are allowed if they do not seriously harm the general appearance or the conservation of fruit of a given consignment:

- defect in shape or colouring
- rough skin
- superficial healed skin alterations

IV. Sizing

The fruit must be sized according to the maximum diameter of their equatorial section.

Grapefruit of less than 70 mm diameter are not admitted.

Size	Diameter in mm	Tolerance
1	114-122	$\pm$ 4 mm
2	105-114	
3	98-105	
4	92-98	
5	88-92	$\pm$ 3 mm
6	85-88	
7	81-85	
8	75-81	
9	70-75	$\pm$ 2 mm

Size tolerances - for all fruit packed in regular layers, and for all classes packed in open or closed packages, 5 per cent by number of fruits per package conforming to the size immediately above or below that stated on the package.

V. Packaging and Presentation

A. Uniformity

Each package, transport vehicle or transport vehicle compartment must contain fruit of the same variety, quality class and size (where required). In addition, for the "Extra" class, uniformity in colouring is required.

B. Packaging

Fruit may be put up in the following ways:

a. arranged in regular layers in closed or open packages (this presentation is compulsory for the "Extra" class)

b. not arranged in layers in closed or open packages

c. in bulk (direct loading into a transport vehicle or transport vehicle compartment).

If the fruit are wrapped, thin, dry new and odourless* paper must be used. The use of any substance tending to modify the natural characteristics of the citrus fruit, especially its taste or smell*, is prohibited.

Any paper or other material used inside the package, transport vehicle or transport vehicle compartment must be new and harmless to human food*.

The package must be free from any foreign bodies, except in the case of a sp presentation admitted by the importing country, where a twig with green leaves adheres to the fruit.

VI. Marking

i. In the case of produce put up in packages, each package must bear on the outside and grouped together on one side, the following particulars, legibly and indelibly marked.

ii. For produce consigned in bulk in a transport vehicle, the following information must be mentioned in a note accompanying the goods and attached to the inside of the vehicle.

a. Packer) Name and address or
   Dispatcher) code mark

b. "Grapefruit", mention of variety is optional

c. District of origin, or nation, regional or local trade name

d. Commercial specifications:

   i. Class

   ii. Size:- reference number for fruit not in bulk

   iii. Where appropriate, mention of diphenyl or other chemical substance used, where such use is compatible with the regulatio of the importing country.

---

* The use of diphenyl or any other chemical substance liable to leave a foreig smell on the skin of the fruit is permitted where it is compatible with the regulations of the importing country.

iv. De-greening - except for the prescribed provisions of the exporting or importing country, the term "de-greening" or "de-greened fruits" is not required on each package, remaining at the discretion of the exporter.

However when it appears that, because of the use of a "de-greening" process, the percentages admitted for fruit having lost their button are likely to be exceeded at destination, the control service will mention the term "de-greening" or "de-greened fruit" on the document accompanying the product.

Source: United Nations AGRI/WP.1/EUR.STAN.18/Rev. 1.

APPENDIX B

UNITED STATES

GRAPEFRUIT IMPORT REGULATIONS

On and after September 30, 1968, the importation of any grapefruit is prohibited unless such grapefruit is inspected and meets the following requirements:-

Seeded Grapefruit - shall grade at least US No. 1 and be of a size not smaller than $3\frac{15}{16}$ inches (100 mm) in diameter, except that a tolerance of 10 per cent by count, of seeded grapefruit smaller than such minimum size shall be permitted.

Seedless Grapefruit - shall grade at least Improved No. 2 and be of a size not smaller than $3\frac{9}{16}$ inches (90 mm) in diameter, except that a tolerance of 10 per cent, by count, of seedless grapefruit smaller than such minimum size shall be permitted. ("Improved No. 2" shall mean grapefruit grading at least US No. 2 and also meeting the requirements of the US No. 1 grade as to shape (form) and colour).

Importers of grapefruit must arrange for inspection of all consignments by the Federal or Federal-State Inspection service, Fruit and Vegetable Division of the US Department of Agriculture. The cost of inspection and certification shall be borne by the applicant thereof.

US Standards for Grades of Florida Grapefruit

US No. 1

- consists of grapefruit which meet the following requirements:-

a. Basic requirements

- not more than one third of the surface, in the aggregate may be affected by discolouration (ie russeting of a light shade of golden brown caused by rust mite or other means).
- fairly smooth texture of skin
- fairly well coloured (ie the yellow colour predominates over the green colour)
- firm

- mature (as defined in the Florida Citrus Code)
- well formed
- fruits in one container should be similar in size and shape

b. Free from:-

- bruises
- cuts not healed
- decay
- growth cracks
- wormy fruit

c. Free from damage caused by:-

- ammoniation
- buckskin
- caked melanose
- dirt or other foreign material
- disease
- dryness or mushy condition
- green spots
- hail
- insects
- oil spots
- scab
- scale
- scars
- skin breakdown
- sprayburn
- sprouting of seeds
- sunburn
- thorn scratches
- other means

US No. 2 "Improved"

- consists of grapefruit which meet the following requirements:-

a. Basic Requirements

- not more than a half of the surface, in aggregate, may be affected by discolouration
- fairly firm (ie the fruit may be slightly soft, but not bruised, and the skin not spongy, or puffy)
- mature
- fairly well coloured
- well-formed
- not more than slightly rough texture
- fruit in one container should be similar in size and shape

b. Free from:-

- bruises
- cuts not healed
- decay
- growth cracks
- wormy fruit

c. Free from serious damage by any other cause.

Standard Pack

a. Fruits shall be fairly uniform in size, unless specified as uniform in size, and when packed in boxes or cartons shall be arranged according to recognised methods. Each wrapped fruit shall be fairly well enclosed by its individual wrapper.

b. All containers shall be tightly packed and well filled, but the contents sha not show excessive or unnecessary bruising because of overfilled package When grapefruit are packed in cartons or wire-bound boxes, each contain shall be at least level full at time of packing.

c. The following ranges of diameters are commonly used in sizing Florida grapefruit:-

Pack Size	Minimum	Maximum
"36"	5"	5 9/16"
"45" or "46"	4 11/16"	5 4/16"
"54" or "56"	4 6/16"	4 15/16"
"64"	4 3/16"	4 12/16"
"70" or "72"	3 15/16"	4 8/16"
"80"	3 12/16"	4 5/16"
"96"	3 9/16"	4 2/16"

d. In order to allow for variations, other than sizing, incident to proper packing, not more than 5 per cent of the packages in any lot may fail to meet the requirements of standard pack.

Sources: Federal Register, Vol. 32, No. 187, 13487-92
Vol. 33, No. 186, 14365

APPENDIX C

FLORIDA GRAPEFRUIT: MATURITY STANDARDS

Seedless Grapefruit

- shall be deemed to be mature only when

a. each grapefruit shows a break in colour, caused solely by nature, with yellow colour predominating on not less than 25 per cent of the fruit's surface.

b. the total soluble solids content of the juice is no less than 7.5 per cent.

c. the ratio of total soluble solids to the anhydrous citric acid is as set forth in the State Citrus Laws 601.17.

d. the juice content of each grapefruit is not less than the minimum requirements for its size as set out hereunder.

Seeded Grapefruit

- shall be deemed to be mature only when

a. each grapefruit shows a break in colour, caused solely by nature, with yellow colour predominating on not less than 25 per cent of the fruit's surface.

b. the total soluble solids content of the juice is not less than 8 per cent.

c. the ratio of total soluble solids to the anhydrous citric acid is as set forth in the State Citrus Laws.

d. the juice content of each grapefruit is not less than the minimum requirements for its size as set out hereunder.

Minimum Juice Content

Diameter	Minimum Juice Content
$5\frac{1}{4}$ inches	360 cc
5 inches	320 cc
$4\frac{3}{4}$ inches	290 cc
$4\frac{1}{2}$ inches	250 cc
$4\frac{1}{4}$ inches	240 cc
$4\frac{1}{8}$ inches	210 cc
4 inches	190 cc
$3\frac{5}{8}$ inches	170 cc

Source:- "Citrus Fruits". H. Harold Hume, MacMillan, New York, 1957, pp. 306-7.

TABLE I

World Production of Grapefruit

Harvesting season commencing in given year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)
Northern Hemisphere												
North America												
United States	1,454	1,612	1,513	1,583	1,566	1,274	1,229	1,488	1,691	2,048	1,586	1,969
Mexico	..	..	..	..	7	10	9	11	11	10	12	12
TOTAL	1,454	1,612	1,513	1,583	1,573	1,284	1,238	1,499	1,702	2,058	1,598	1,981
Mediterranean												
Israel	62	70	73	68	73	97	134	157	183	217	256	268
Cyprus	8	8	8	9	13	13	15	21	23	31	35	37
Morocco	10	11	8	13	15	10	12	13	16	17	19	13
Spain	1	2	2	4	4	4	5	4	4	7	6	7
Lebanon	..	..	..	2	2	3	3	3	..	..	..	..
Turkey	2	2	2	2	2	2	2	3	3	3	4	..
Algeria	5	5	6	7	7	6	3	4	5	3	3	3
Portugal	-	-	-	-	1	2	2	2	(2)	(2)	5	..
TOTAL	88	98	99	105	117	137	176	207	236	280	328	..
Far East												
Philippines*	11	20	19	22	19	22	22	20	23	25	27	..
Taiwan*	7	7	7	7	8	7	7	9	10	11	12	..
TOTAL	18	27	26	29	27	29	29	29	33	36	39	..
Caribbean												
Jamaica	17	16	18	19	21	27	27	30	34	37	26	22
Trinidad	33	18	35	22	29	20	21	35	28	23	18	16
Puerto Rico	11	9	9	14	15	18	16	14	15	12	10	..
Cuba	7	7	7	7	7	7	9	10	11	11	(15)	..
British Honduras	7	7	8	9	4	8	11	9	9	8	8	10
Surinam	3	5	6	5	2	7	7	7	5	6	6	7
Honduras Republic	..	..	..	..	..	..	2	(3)	(3)	(3)	(3)	..
TOTAL	78	62	83	76	78	87	91	108	105	100	(86)	..
Southern Hemisphere												
South Africa	14	15	18	22	23	34	43	57	60	64	(76)	(88)
Mozambique	2	3	4	4	4	5	5	6	6	6	(6)	..
Swaziland	..	..	..	..	..	..	2	2	4	4	(4)	..
Argentina	20	28	30	32	40	47	49	60	72	80	85	83
Australia	6	7	7	7	8	9	9	9	9	8	9	7
New Zealand*	2	2	3	3	3	4	3	3	3	3	3	3
TOTAL	44	55	62	68	78	99	111	137	154	165	183	..
Grand Totals	1,682	1,854	1,783	1,861	1,873	1,634	1,635	1,980	2,230	2,639	(2,234)	(2,630)

(a) Preliminary .. Not available * Includes citrus hybrids similar to grapefruit ( ) Unofficial estimate

GRAPEFRUIT

Exports from Israel

		1959	1960 & 62 Average*	1963	1964	1965	1966	1967	1
TOTAL	Tons	45,749	52,353	64,529	82,256	91,201	110,545	121,949	15
	£'000	2,321	2,400	3,184	3,533	3,942	4,972	5,425	7
of which to:-									
Belgium	Tons	2,563	3,825	3,909	4,950	6,766	7,600	7,180	10
	£'000	...	173	210	213	283	335	339	
Denmark	Tons	1,700	1,539	1,834	1,557	1,901	1,367	1,812	1
	£'000	...	75	87	75	86	64	86	
Finland	Tons	944	742	841	1,052	1,681	1,801	1,621	1
	£'000	...	39	40	51	81	87	79	
France	Tons	8,266	8,886	11,716	14,817	19,515	20,990	25,419	33
	£'000	...	440	540	698	911	1,033	1,189	1
Germany	Tons	8,477	9,994	15,952	16,431	23,165	30,098	34,545	41
	£'000	...	471	830	759	1,035	1,346	1,493	2
Italy	Tons	-	-	-	400	1,207	3,258	3,279	5
	£'000	-	-	-	19	56	165	158	
Netherlands	Tons	1,442	1,853	2,537	5,954	5,219	5,096	6,777	9
	£'000	...	69	121	224	205	197	325	
Norway	Tons	639	587	639	552	766	746	727	
	£'000	...	27	31	27	35	35	35	
Sweden	Tons	1,061	1,331	2,001	2,100	2,663	2,430	2,173	2
	£'000	...	65	95	101	120	114	104	
Switzerland	Tons	5,015	3,326	5,957	6,199	4,931	5,087	6,510	6
	£'000	...	238	281	298	232	253	331	
United Kingdom	Tons	14,489	18,970	17,204	26,288	21,615	29,640	29,185	36
	£'000	...	735	863	977	818	1,224	1,153	1
Other Countries	Tons	1,153	1,300	1,939	1,956	1,772	2,432	2,721	3
	£'000	...	68	86	91	80	119	133	

... Information not available   - Nil or negligible   * 1961 shows quantiti only

Source: Israel Foreign Trade, Central Bureau of Statistics

GRAPEFRUIT

TABLE III

Exports from the United States

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968
TAL	Tons	73,205	89,923	70,990	73,914	87,497	95,790	114,871	78,659
	£'000	2,906	3,448	3,769	4,058	4,069	4,734	5,084	5,064
which to:-									
nada	Tons	52,930	60,872	48,115	46,786	58,999	68,942	83,819	64,065
	£'000	1,934	2,057	2,418	2,463	2,545	3,167	3,322	3,997
lgium	Tons	3,055	2,076	1,754	2,284	2,178	2,082	2,408	1,152
	£'000	152	103	110	145	133	129	150	90
nmark	Tons	149	495	199	464	355	275	396	91
	£'000	8	23	14	25	20	15	23	6
nland	Tons	3	146	266	460	419	149	135	-
	£'000	-	7	15	28	20	8	6	-
ance	Tons	392	5,219	6,650	7,392	8,507	9,559	10,657	5,286
	£'000	17	237	407	427	441	550	595	350
rmany	Tons	4,766	4,468	2,310	3,466	3,404	2,343	3,166	624
	£'000	217	188	118	181	147	119	142	53
pan	Tons	25	432	532	827	743	1,096	1,180	1,223
	£'000	2	23	38	59	50	92	97	121
herlands	Tons	6,354	8,507	7,464	8,124	7,890	7,672	7,726	3,210
	£'000	317	469	437	484	453	446	464	236
way	Tons	498	370	197	299	613	524	647	334
	£'000	21	19	11	20	34	33	43	28
den	Tons	1,053	1,225	1,168	1,902	2,522	1,559	1,682	1,551
	£'000	54	67	64	115	135	89	90	105
tzerland	Tons	1,529	842	316	138	121	81	85	-
	£'000	74	39	23	9	6	6	5	-
ted Kingdom	Tons	1,913	4,236	1,083	1,105	1,115	645	1,263	218
	£'000	81	175	66	68	55	39	65	17
er Countries	Tons	538	1,035	936	667	631	863	1,707	905
	£'000	29	41	48	34	30	41	82	61

- Nil or negligible

Source: Bureau of the Census Report FT 410, Department of Commerce

GRAPEFRUIT

TABLE IV

Exports from Republic of South Africa

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	19 (a
TOTAL	Tons	10,823	17,416	29,587	31,983	34,182	47,094	46,743	56,
	£'000	672	847	1,162	1,699	1,836	1,889	2,308	2,
of which to:-									
Canada	Tons	-	-	-	-	-	281	430	..
	£'000	-	-	-	-	-	8	11	..
Belgium	Tons	29	194	465	370	-	-	404	..
	£'000	1	6	20	21	-	-	24	..
Denmark	Tons	18	105	81	92	118	257	134	..
	£'000	1	4	4	6	7	13	6	..
Finland	Tons	168	125	177	151	220	344	297	..
	£'000	10	6	9	8	12	14	14	..
France	Tons	-	523	1,431	4,867	5,182	6,556	7,334	..
	£'000	-	20	89	254	287	282	312	..
Germany	Tons	32	817	1,219	4,335	5,364	11,105	10,890	..
	£'000	3	37	64	218	296	491	560	..
Italy	Tons	-	-	-	-	-	-	1,084	..
	£'000	-	-	-	-	-	-	59	..
Netherlands	Tons	9	380	510	212	-	164	-	...
	£'000	-	13	16	9	-	8	-	...
Norway	Tons	6	75	177	-	184	250	172	...
	£'000	-	2	6	-	10	9	9	...
Sweden	Tons	53	293	173	149	198	238	-	...
	£'000	2	10	8	6	12	9	-	...
Switzerland	Tons	51	185	516	613	335	755	884	...
	£'000	3	9	28	36	22	37	52	...
United Kingdom	Tons	10,311	14,540	15,709	20,907	21,899	26,679	24,019	...
	£'000	643	730	910	1,128	1,161	995	1,203	...
Other Countries	Tons	146	179	129	287	682	465	1,095	...
	£'000	9	10	8	13	29	23	58	...

- Nil or negligible ... Information not available

(a) From December summary

Source: Foreign Trade Statistics, Department of Customs and Excise

FRESH GRAPEFRUIT

TABLE V

Exports from Cyprus

		1962	1963	1964	1965	1966	1967	1968 (a)
TOTAL	Tons	9,580	12,590	15,810	24,822	19,674	32,300	32,735
	£'000	306.0	441.1	526.1	920.1	860.2	1,451.6	1,486.1
of which to:-								
United Kingdom	Tons	7,510	9,380	11,000	14,571	10,496	15,803	17,268
	£'000	247.8	351.4	378.4	529.2	471.7	776.1	812.7
West Germany	Tons	800	1,220	2,020	3,386	3,089	9,460	8,548
	£'000	18.2	30.3	54.1	115.5	124.9	376.9	364.4
France	Tons	510	960	700	1,089	1,374	559	773
	£'000	13.3	24.7	27.6	48.0	65.1	29.5	36.4
Czechoslovakia	Tons	460	160	670	3,020	1,967	1,465	819
	£'000	16.9	4.1	19.8	118.7	75.7	67.6	39.0
Denmark	Tons	10	40	90	177	122	75	-
	£'000	0.2	1.0	2.3	7.7	6.5	4.0	-
Netherlands	Tons	-	-	80	567	638	1,329	2,269
	£'000	-	-	2.7	18.9	25.1	50.7	100.9
Switzerland	Tons	60	20	210	863	383	655	1,186
	£'000	0.9	0.2	5.2	30.6	17.0	28.4	48.4
Belgium	Tons	-	-	-	38	94	239	212
	£'000	-	-	-	2.0	5.0	12.5	10.5
Italy	Tons	-	-	60	-	38	94	487
	£'000	-	-	2.1	-	1.4	3.2	18.0
East Germany	Tons	-	-	-	608	932	1,020	-
	£'000	-	-	-	28.0	44.6	39.8	-
Finland	Tons	-	-	-	-	-	-	179
	£'000	-	-	-	-	-	-	7.4
Other Countries	Tons	230	810	940	503	541	1,601	1,014
	£'000	8.7	29.4	33.1	21.5	23.2	62.9	48.4

Not separately shown before 1962

(a) Provisional
\- Nil or negligible

Source: Statistics of Imports and Exports
Ministry of Finance

GRAPEFRUIT

Imports into the United Kingdom

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967
TOTAL	Tons	45,590	60,441	56,822	72,462	71,075	75,382	79,801
	£'000	3,168	3,860	3,975	4,604	4,453	4,908	5,618
of which from:-								
Israel	Tons	16,009	16,897	16,743	25,196	22,028	29,465	27,590
	£'000	1,069	1,043	1,157	1,552	1,334	2,084	1,749
South Africa	Tons	9,688	13,657	15,073	20,192	19,629	17,027	17,393
	£'000	822	975	1,170	1,452	1,440	1,141	1,442
Cyprus	Tons	5,309	7,307	7,801	10,102	15,780	11,377	14,562
	£'000	306	394	443	506	787	602	807
Swaziland	Tons	-	-	596	1,239	1,797	4,234	5,724
	£'000	-	-	51	87	98	260	503
Mozambique	Tons	1,045	1,610	1,208	1,855	1,843	2,192	3,894
	£'000	78	108	103	120	145	148	325
Windward Is.	Tons		724	676	1,136	1,203	1,380	1,877
	£'000		46	25	42	43	48	70
Jamaica	Tons	6,557	1,700	2,563	1,512	1,988	1,095	1,724
	£'000	406	110	185	117	164	105	187
Trinidad	Tons		6,628	4,389	2,947	2,296	4,226	2,035
	£'000		397	262	170	110	174	97
British Honduras	Tons	396	938	1,096	1,126	-	-	-
	£'000	26	74	88	72	-	-	-
Brazil	Tons	593	1,266	1,964	1,433	672	130	118
	£'000	40	83	148	102	47	9	10
Spain	Tons	701	747	914	848	738	1,102	802
	£'000	48	54	64	53	54	89	70
Morocco	Tons	12	1,811	1,245	1,157	407	923	1,055
	£'000	1	125	91	76	35	84	105
United States	Tons	2,151	4,276	789	1,291	1,044	533	1,446
	£'000	146	267	65	101	75	48	115
Other Countries	Tons	3,129	2,880	1,765	2,428	1,650	1,698	1,581
	£'000	226	184	123	154	121	116	138

- Nil or negligible

Source: The Trade of the United Kingdom, H.M. Customs and Excise

Imports Into Canada

TABLE VII

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968
TOTAL of which from:-	Tons	59,738	66,818	49,733	54,254	66,735	63,283	80,921	68,497
	£'000	2,072	2,118	2,421	2,682	2,675	2,765	3,107	4,196
Hong Kong	Tons	10	11	13	10	7	5	18	29
	£'000	1	1	1	1	1	-	1	3
South Africa	Tons	-	27	-	90	292	413	521	1,139
	£'000	-	1	-	4	14	14	37	65
Brazil	Tons	-	-	-	-	38	-	-	152
	£'000	-	-	-	-	-	-	-	5
Cuba	Tons	56	61	-	1,393	285	327	214	242
	£'000	3	3	-	59	11	13	17	13
Honduras	Tons	595	638	79	-	-	-	-	-
	£'000	28	24	3	-	-	-	-	-
Jamaica	Tons	3	8	44	53	34	14	37	28
	£'000	-	-	3	3	3	1	3	3
Mexico	Tons	8	5	43	213	46	85	-	503
	£'000	-	-	2	11	1	4	-	41
United States	Tons	59,038	66,051	49,554	52,490	66,033	62,438	80,130	66,403
	£'000	2,038	2,087	2,412	2,604	2,645	2,733	3,057	4,064
Other Countries	Tons	35	17	-	5	-	1	1	1
	£'000	2	2	-	-	-	-	2	2

Source:- TRADE OF CANADA
DOMINION BUREAU OF STATISTICS

- nil or negligible

TABLE VIII

Grapefruit

Imports into the German Federal Republic

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1
TOTAL	Tons	19,051	25,275	34,271	40,810	49,385	59,743	61,792	73
of which from:-	£'000	1,205	1,532	2,246	2,535	3,069	3,571	3,784	4
Israel	Tons	6,919	9,370	15,757	16,251	22,306	29,366	30,710	46
	£'000	413	537	971	940	1,287	1,657	1,737	2
United States	Tons	8,013	7,377	5,330	6,026	5,782	4,564	3,881	
	£'000	510	490	412	443	392	302	264	
South Africa	Tons	86	1,219	2,070	4,355	5,944	9,605	11,176	8,
	£'000	7	86	160	349	459	730	957	
Cyprus	Tons	137	443	752	2,182	3,063	5,173	7,486	9,
	£'000	9	23	38	112	147	247	348	
Honduras Republic	Tons	164	465	995	2,880	3,477	3,763	2,446	2,
	£'000	13	25	65	158	217	201	135	
Spain	Tons	1,262	992	1,481	1,511	1,670	1,162	1,382	1,
	£'000	100	61	91	103	132	88	74	
Morocco	Tons	607	1,503	1,840	3,405	1,968	1,961	837	
	£'000	49	80	102	179	110	108	39	
Algeria	Tons	164	1,182	1,173	506	857	320	581	
	£'000	18	85	83	32	50	22	40	
Brazil	Tons	81	329	1,653	787	1,170	853	812	
	£'000	5	21	145	55	90	49	50	
Paraguay	Tons	51	10	151	333	895	439	-	
	£'000	3	-	11	23	67	22	-	
Jamaica, Trinidad etc	Tons	405	871	1,264	839	611	793	1,638	
	£'000	22	48	70	49	31	41	83	
Surinam	Tons	277	103	273	146	62	54	142	
	£'000	17	5	17	8	3	3	10	
Cuba	Tons	66	-	-	-	-	-	189	
	£'000	4	-	-	-	-	-	11	
Other Countries	Tons	819	1,411	1,532	1,589	1,580	1,690	512	1,
	£'000	35	71	81	84	84	101	36	

- Nil or negligible

Source:- Aussenhandel, Statistisches Bundesamt.

Grapefruit

TABLE IX

Imports into France

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968
OTAL	Tons	17,250	21,760	26,577	33,002	36,849	40,466	46,378	53,125
ich from:-	£'000	1,026	1,194	1,731	2,081	2,254	2,725	3,389	4,007
el	Tons	7,138	8,352	11,100	15,163	18,800	20,898	23,276	36,760
	£'000	388	411	605	816	993	1,246	1,556	2,565
ed States	Tons	474	5,329	6,328	7,659	7,366	8,952	9,946	4,799
	£'000	28	365	530	595	518	714	847	506
Africa	Tons	-	454	2,053	4,580	5,045	4,471	6,609	4,730
	£'000	-	27	165	347	410	372	514	355
cco	Tons	5,114	3,672	2,085	1,274	1,453	1,245	2,330	898
	£'000	297	174	119	70	79	67	151	52
ria	Tons	2,786	2,649	1,900	1,877	1,431	1,049	1,198	443
	£'000	184	137	121	105	83	56	79	26
as	Tons	-	-	1,024	645	1,191	1,012	857	825
	£'000	-	-	48	31	54	51	46	50
	Tons	-	-	221	302	396	605	427	570
	£'000	-	-	13	15	24	50	35	54
	Tons	-	-	-	-	-	-	-	1,153
	£'000	-	-	-	-	-	-	-	98
ras Rep.	Tons	-	-	263	716	481	547	345	883
	£'000	-	-	17	42	41	46	29	78
am	Tons	135	154	347	202	232	277	368	727
	£'000	13	12	29	20	25	28	38	101
bique	Tons	954	404	527	89	-	1,024	-	-
	£'000	69	24	35	6	-	77	-	-
	Tons	-	-	-	-	-	-	547	262
	£'000	-	-	-	-	-	-	57	32
alia	Tons	-	-	-	-	-	-	96	74
	£'000	-	-	-	-	-	-	9	8
Countries	Tons	649	746	729	495	454	386	379	1,001
	£'000	47	44	6	34	27	18	28	82

- Nil or negligible

Source:- Commerce Exterieur, Direction Générale des Douanes et Droits Indirects

TABLE X

Grapefruit

Imports into the Netherlands

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967
TOTAL of which from:	Tons	4,733	7,687	9,704	11,099	12,120	11,862	15,412
	£'000	226	350	488	543	614	628	941
Israel	Tons	1,227	1,539	2,586	5,061	4,811	4,382	6,567
	£'000	63	71	144	229	218	233	364
United States	Tons	2,032	2,863	2,266	2,349	2,679	2,898	3,290
	£'000	103	139	129	142	165	175	241
Surinam	Tons	1,084	1,634	2,010	1,169	1,948	1,825	1,995
	£'000	41	67	94	51	97	97	112
Honduras	Tons	-	12	280	436	532	1,025	246
	£'000	-	-	12	14	25	37	13
Brazil	Tons	20	203	175	194	352	204	295
	£'000	-	7	10	5	12	5	15
Paraguay	Tons	-	13	-	-	346	222	554
	£'000	-	-	-	-	21	8	34
South Africa	Tons	-	213	312	280	156	145	105
	£'000	-	10	15	15	8	11	7
Cyprus	Tons	12	-	-	18	312	120	325
	£'000	-	-	-	1	13	4	13
Spain	Tons	17	50	46	127	66	266	233
	£'000	1	2	2	6	3	14	17
Morocco	Tons	16	223	712	212	47	-	175
	£'000	-	9	19	10	2	-	18
Cuba	Tons	-	-	-	-	-	-	-
	£'000	-	-	-	-	-	-	-
Belgium	Tons	185	280	532	611	384	374	1,216
	£'000	10	14	32	41	26	25	87
Other Countries	Tons	140	657	785	642	487	401	411
	£'000	8	31	31	29	24	19	20

- Nil or negligible

Source:- Maandstatistiek van de In-Uit-Voer, Centraal Bureau voor de Statistiek

Imports into Belgium - Luxembourg

TABLE XI

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968
TOTAL	Tons	6,215	5,980	6,580	8,593	9,381	9,686	11,111	11,877
of which from:-	£'000	323	297	346	439	480	520	643	710
Netherlands	Tons	699	543	373	555	575	-	-	-
	£'000	39	27	23	28	29	-	-	-
Israel	Tons	2,624	2,971	3,340	4,813	5,991	6,909	7,306	8,723
	£'000	127	140	160	237	286	356	381	519
South Africa	Tons	-	-	382	-	-	-	-	-
	£'000	-	-	23	-	-	-	-	-
United States	Tons	2,595	2,027	1,949	2,491	2,231	2,335	2,753	-
	£'000	141	107	111	134	131	138	193	-
Other Countries	Tons	297	439	536	734	584	442	1,052	3,154
	£'000	16	23	29	40	34	26	69	191

Source:- Commerce Exterieur

L'Institut National de Statistique

\- Nil or negligible

GRAPEFRUIT — Imports Into Switzerland — TABLE XII

		1960-62 Average	1963	1964	1965	1966	1967	1968
TOTAL	Tons	6,603	7,042	8,279	7,464	7,681	9,856	9,023
of which from:-	£'000	402	461	532	519	519	672	641
Cyprus	Tons	32	28	103	736	634	588	1,028
	£'000	2	1	7	56	36	35	59
Italy	Tons	12	14	35	22	46	52	22
	£'000	-	1	2	1	3	3	2
Spain	Tons	196	174	151	161	121	191	102
	£'000	11	10	9	11	7	12	6
Israel	Tons	4,682	5,441	6,354	5,093	5,039	6,701	6,655
	£'000	262	317	375	306	315	403	462
Mozambique	Tons	46	37	14	-	8	13	76
	£'000	3	3	1	-	1	1	6
South Africa	Tons	309	570	656	423	644	1,075	825
	£'000	23	54	56	44	60	110	75
Brazil	Tons	13	40	-	81	77	168	34
	£'000	1	4	-	8	5	13	2
United States	Tons	1,218	643	842	914	1,058	1,038	276
	£'000	92	65	73	90	88	93	28
Other Countries	Tons	95	95	124	34	54	30	5
	£'000	8	6	9	3	4	2	1

Source:- Statistique de la Suisse

Bureau Federal de Statistique

Not separately shown before 1960

GRAPEFRUIT

Imports Into Italy

TABLE XIII

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968 (a)
TOTAL	Tons	154	269	313	686	1,558	3,361	4,891	6,499
of which from:-	£'000	8	14	16	44	98	229	353	432
France	Tons	-	-	-	-	-	-	63	177
	£'000	-	-	-	-	-	-	7	12
Netherlands	Tons	-	-	-	48	55	97	-	-
	£'000	-	-	-	5	5	7	-	-
Israel	Tons	-	-	-	323	1,108	2,866	3,298	5,368
	£'000	-	-	-	21	67	198	218	354
Somalia	Tons	152	193	243	176	286	214	161	-
	£'000	8	10	13	8	18	10	8	-
South Africa	Tons	-	-	-	-	-	123	1,247	-
	£'000	-	-	-	-	-	10	113	-
Venezuela	Tons	-	-	-	28	82	59	118	-
	£'000	-	-	-	2	6	4	7	-
Other Countries	Tons	2	76	70	111	27	2	4	954
	£'000	-	4	3	8	2	-	-	66

Source:- Comercio Con L'Estero

Instituto Centrale Di Statistica

\- Nil or negligible

(a) from December summary

APPENDIX E

Method of Projection of Consumption of Fresh Grapefruit to 1975 based on observations in 1960 to 1968 inclusive

Prepared by R Pope of the Statistics Section, TPI

Consumption of fresh grapefruit has risen in the period of observation, much faster than can be explained by normal population increases in the consuming countries.

In addition to the apparent year to year increase, there is a tendency for impor and consumption to be greater in years of good supply and low prices, than in years of short supply and high prices.

In the first stage an attempt is made to eliminate the fluctuations caused by variations in price. For each importing country, the average import price is deflated by the general consumer price index in each year for comparability. Consumption figures are expressed in lbs. per caput. A linear multiple regression equation of the form:-

$$y_1 = a + b_1 x_1 + b_2 x_2$$

is obtained by the Principle of Least Squares.

y_1 = per caput consumption in lbs.

x_1 = the number of the year, counting 1964 as zero.

x_2 = the deflated average price of imports of fresh grapefruit, in national currency units.

The constants a, b_1 and b_2 are estimated from the data, and are the best possibl in the sense that the sum of the squares of the differences between the observed values of y_1, and those predicted by the equation, is the least possible.

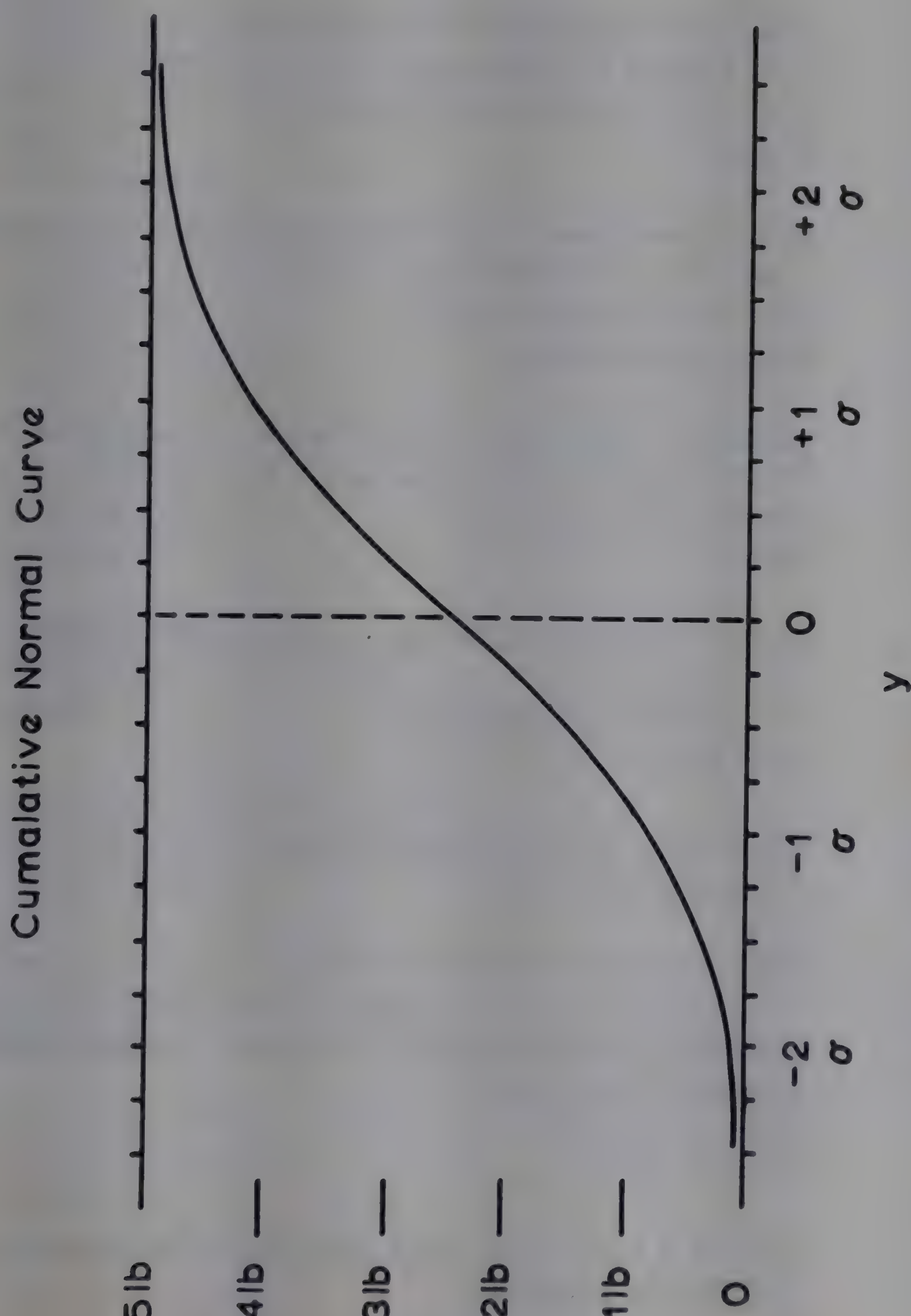
From the coefficient b_2 corrections are obtained, to give estimates of what per caput consumption in each year would have been, if the deflated price had been constant throughout the period.

In the second stage, it is assumed that the per caput consumption is moving fro one level, taken as a convenient figure a little below the 1960 estimate, to a new higher level about which it will eventually settle. The model used is the sigmoid or Cumulative Normal curve, which has a rather exotic formula but a very simple form as shown in the diagram. The proportion of the difference between levels is expressed in terms of the distance along the base line.

For comparability between countries, the upper level has been so chosen, that in each case the projection for ten years after the end of the base period, that is to 1978, results in an estimate of 90% of the total increase. That is, if the original level is 1 lb and the upper level 2 lb, the 1978 estimate should be 1.9 lb.

Projections of population to 1975 are then used to estimate total consumption from the per caput figures. The average of 1960 to 1968 deflated prices is assumed to be normal.

In most cases, prices of fresh grapefruit have been rising less rapidly than has the consumer price index, so that in real terms grapefruit was cheaper in 1966 to 1968 than in 1960 to 1962. There is an opposite trend in Canada, and no significant trend in France or Italy. In all other consuming countries, prices towards the end of the base period are in real terms significantly less than the 1960 to 1968 average. If they remain so, the consumption figures are likely to be higher than estimated.



INFORMATION ON TRADE CONTACTS

The firms and organisations contacted in the course of this study are listed below. There are other importers of grapefruit, especially on the Continent; potential exporters are advised to contact the national trade federations for names of other importers.

NATIONAL TRADE FEDERATIONS:-

Belgium	:	Fédération Nationale des Importateurs, Exportateurs et Grossistes en Fruits, Légumes et Primeurs 68 Boulevard d'Ypres Brussels 1
Canada	:	Canadian Fruit Wholesalers' Association 219 Queen Street Ottawa 4
France	:	Chambre Syndicale d'Importation et de Distribution de Fruits et Légumes C.S.I.D. 55 Rue de Rivoli Paris 1
Germany	:	Zentralverband des Deutschen Fruchte-Import und-Grosshandels eV Von Groote Strasse 7 Koln-Marienburg
Italy	:	Sindicato Nazionale Esportatori Importatori Ortofrutticoli e Agrumari Piazza G.G. Belli 2 Roma
Netherlands	:	Dutch Federation of the Fruit and Vegetable Import Trade Bezuidenhoutseweg 82 The Hague
Switzerland	:	Schweizerischer Obsteverband Baarerstrasse 88 Zug Switzerland
United Kingdom	:	National Federation of Fruit and Potato Trades Ltd Russell Chambers Covent Garden London WC2
United States	:	United Fresh Fruit and Vegetable Association 827 Wyatt Building 777, 14th Street, N.W. Washington D.C. 20005

FIRMS AND ORGANISATIONS CONTACTED BY TPI

Inclusion in this list does not imply that TPI has any knowledge of the financial standing of the firms.

Cowling (Wholesale Fruit Merchants) Ltd
Wholesale Markets
Pontefract Lane
Leeds

Connolly Shaw (Anderson) Ltd
Liverpool Fruit Exchange
10-18 Victoria Street
Liverpool 2

Fyffes Group
15 Stratton Street
London

Geest Industries Ltd
White House Chambers
Spalding
Lincolnshire

Gillespie Bros & Co
Ling House
Dominion Street
London EC2

R E Jenkinson Ltd
35 King Street
London WC2

Walter Lund Ltd
Wholesale Fruit Market
Leeds

Geo Monro (Produce) Ltd
43 King Street
Covent Garden

Francis Nicholls (Northern) Ltd
89/97 Wholesale Market
Liverpool

T J Poupart Ltd
107/115 Long Acre
London WC2

Prime Fruit Importers
15 Victoria Street
Liverpool 2

Louis Reece Ltd
69/73 Brushfield Street
London E1

Ridley & Houlding Ltd
10 Russell Street
London WC2

J Sainsbury
Stamford House
Stamford Street
London SE1

Saphir Sons & Co Ltd
London Fruit Exchange
London E1

J O Sims Ltd
Borough Market
London SE1

J M Turnell
17 New Row
London WC2

Dan Wuille & Co Ltd
100/104 Long Acre
London WC2

Citrus Marketing Board of Israel
Wellington House
Upper St Martin's Lane
London WC2

Italian Institute for Foreign Trade
31 Old Burlington Street
London W1

The Outspan Organisation
6 Henrietta Street
London WC2

Afrikanische Frucht-Compagnie Laeisz & Co
Trostbrucke 1
Postfach 2304
2 Hamburg 11
West Germany

A.S.K. Centrallen AB
Rannerbanan 12
252 30 Halsingborg
Sweden

Compagnie des Bananes
23 Rue Auguste Vaequerie
Paris 16
France

Compagnie Fruitiere
33 Boulevard F. de Lesseps
13 Marseille 14
France

Albert Heijn
Zaandam
26 Westzijde
Amsterdam
Holland

Kooperativa Förbundet
Fack, S-104 65
Stockholm 15
Sweden

Moller & Co AB
23-25 Importorvägen
S-12173 Johanneshov
Stockholm
Sweden

Albert Nataf
52 Cours Julian
Marseille
France

Société Cofa
17 Rue Turbigo
Paris 1
France

Société Pomona
1c, Rue de Toulouse
M.I.N. de Paris - Rungis
94 - Rungis
France

Ets S. Tedesco et Cie
170 Cours Charlemagne
Lyon 2
France

Velleman en Tas N.V.
Fruit Exchange
Rotterdam
Holland

Waco
110 Boulevard des Dames
Marseille
France

Tropical Products Institute

G 49 Particle boards from Cyprus-grown trees

Tropical Products Institute Report

G 49

Particle boards from Cyprus-grown trees

A.E.Chittenden L.J.Flaws A.J.Hawkes

May 1970

Tropical Products Institute
Ministry of Overseas Development
56/62 Gray's Inn Road London WC1

This report was produced by the Tropical Products Institute, a British Government organisation which helps developing countries to derive greater benefit from their renewable resources.

It specialises in post-harvest problems and will be pleased to answer requests for information and advice. Reports such as this one are often written as the result of an enquiry.

Requests for further information should be addressed to:

The Director,
Tropical Products Institute,
56/62 Gray's Inn Road,
London, WC1

Particle boards from Cyprus-grown trees

INTRODUCTION

Following a visit to the Republic of Cyprus by a member of staff of the Tropical Products Institute, a request was received from the Forests Department of the Ministry of Agriculture and Natural Resources, to examine the wood from seven different species of locally-grown trees and assess the suitability of the wood for use in the manufacture of particle boards.

Description of samples

The samples consisted of debarked logs, 4 to 6 feet in length and 3 to 19 inches in diameter, which were described by the Acting Director of the Department of Forests, as:

a. *Pinus brutia,* from the crown of an over mature tree, from the trunk of an old tree and some branches. About 60 tons is available on site daily and of this weight about half is sawmill waste and the remainder 'tops' and branches which are unsuitable for sawmilling.

b. *Pinus nigra,* from the crowns of both an old and a young tree, some resinous heartwood and a number of branches. 3½ tons are available daily, one third in the form of sawmill waste and the rest from 'tops' and branches.

c. *Acacia cyanophylla,* from coppice; about 3½ tons are available daily for board-making.

d. *Quercus alnifolia,* about 2 tons are available for boardmaking daily.

e. *Alnus orientalis,* about ¾ ton available daily.

f. *Eucalyptus gomphocephala* and *Eucalyptus camaldulensis,* used at present exclusively in Cyprus for the production of parquet flooring but these species were included since a knowledge of their board-making properties may well be of use in the future.

Preparation of samples

Each sample was examined separately for its boardmaking possibilities and so that the results could be compared, the method of preparation of each sample was identical. The logs were cut into billets 10 inches long and placed in a soaking tank containing fresh water for seven days. They were then removed and flaked in a machine specially designed to enable the lengths and thicknesses of the wood particles to be varied. After discharge from the flaking machine, the flakes were dried in a tray drier, from a moisture content of about 50 per cent to between 3 and 5 per cent.

Where a reduction in the width of the flakes was needed, they were passed through a

hammermill in which the screen size can be altered to obtain the width required. For example, flakes with an original width of ¾ to 1½ inches can be reduced to $\frac{1}{16}$ to ¼ inch wide particles,using a ½ inch screen, $\frac{1}{16}$ to $\frac{1}{8}$ inch from a $\frac{3}{8}$ inch screen,and so on.

Boardmaking

Particle boards of overall dimensions 14½" x 14½" x ¾" and of density 40± 2 lb/cu.ft. were made by spraying a quantity of wood flakes in a rotary mixer with urea formaldehyde liquid resin containing 68 per cent of resin solids to which was added a hexamine/ammonium chloride hardener equivalent in weight to 10 per cent of the resin used.

A predetermined weight of the sprayed flakes was placed in a rectangular metal mould and after cold prepressing, the mould was removed and the mat placed in an electrically heated hydraulic press where it remained for 15 minutes under a pressure of 150 p.s.i., with platen temperature maintained at 140°C. Each finished sample board was subsequently cut into a number of test pieces and allowed to cure for seven days before being subjected to tests specified in BS No.2604: 1963.

During the preliminary stages of the investigation, boards were made from flakes of different dimensions from which the fines – i.e. that portion passing through a No.22 BS Sieve – were removed, whilst the weight of resin added to the flakes before pressing, remained constant at 8.0 per cent of the weight of dried flakes used. Later, using flakes of optimum dimensions to give maximum strength, the resin content was varied and boards were made from flakes from which the fines had been removed and also from unscreened flakes containing the fines. Wax emulsion was also added in some cases.

Board testing

The modulus of rupture (bending stress) was determined on test pieces 8 inches x 3 inches, supported on parallel metal rollers which were free to rotate on roller bearings. The distance between the rollers was 6 inches and the bending load was applied to the centre of the span.

To determine the tensile stress prependicular to the plane of the board, test pieces 1½ inches x 1½ inches were glued between two pieces of suitable wood, with the glue line on the top and bottom faces of the test piece. A tensile load was then applied to the sample until it failed.

To measure the resistance to the withdrawal of wood screws from particle board – i.e. screw-holding – test pieces 3 inches x 3 inches were prepared. Into each test piece, three 1½ inch long No.6 wood screws were inserted, one at the midpoint of a surface and one at each of two adjacent edges. The axial load required to withdraw each screw was then determined.

In all cases, the rate of loading was as specified by the British Standard.

Water absorption was measured by submerging test pieces, 8 inches x 3 inches, for one hour in water at a temperature of 18°C. The difference in weight before and after immersion, expressed as a percentage of the initial weight, is termed the water absorption. Thickness swelling is the increase in thickness of the 8 inches x 3 inches test pieces after submersion in water for one hour, expressed as a percentage of the initial thickness.

TEST RESULTS

Pinus brutia

Table 1 shows the results of the preliminary tests carried out on boards made from flakes of different dimensions. Using 8 per cent of resin, boards made from milled flakes between 0.6 and 1.6 inches long and 0.008 and 0.032 inches thick, all exceeded the BSS for modulus of rupture. Those boards made from unmilled flakes and those made from flakes milled through a ½ inch screen, have approximately the same modulus of rupture values. On the other hand, the mean value for those boards made from flakes milled through a ¾ inch screen is a little lower. None of the boards made from unmilled flakes complied with the BSS for tensile strength perpendicular to plane. However, flakes milled through ½ inch and ¾ inch screens met the BSS in this respect. Both screw holding properties and water absorption figures exceeded BSS for all boards made from this species. In general however, the best results were obtained from flakes milled to pass the ½ inch screen.

Table 2 shows the results of further tests carried out on boards made from flakes of *Pinus brutia* milled to constant width. The flakes prepared had lengths of 0.6, 0.8, 1.2 and 1.6 inches and thicknesses of 0.008, 0.016, 0.024 and 0.032 inches and were then milled to pass a half-inch screen.

With flake lengths of 0.6 and 0.8 inches, the modulus of rupture is at a maximum when the thickness of 0.008 or 0.024 inches. With the lengths of 1.2 and 1.6 inches however, the maximum occurs between thicknesses of 0.016 and 0.024 inches.

The effect of alterations in the length of flake when the thickness is kept constant is not so clearly defined; it would appear however, that within the limits of experimental error, the strength of the board remains about the same over the range of flake length from 0.6 to 1.6 inches for each of the flake thicknesses used. The water absorption and screw holding characteristics do not appear to be influenced to any great extent by changes in thickness or length of flake but there is some evidence that boards having the highest tensile stress are made from flakes 0.016 inches or 0.024 inches thick.

Pinus nigra

Table 3 shows two sets of results from tests carried out on boards made from *Pinus nigra*. In the first set, flakes of 1.2 inches length and 0.024 inches thickness were milled to pass a ½ inch screen. These were then mixed with three different proportions of resin with and without inclusion of the fines.

For the second set, these conditions were repeated with material milled through a ¾ inch screen instead of a ½ inch screen. In both cases there is very little difference between the strength of the boards as indicated by the modulus of rupture. Also, the width of the milled flakes,as indicated by the screen size, does not appear to have any appreciable effect on the board strength. Further, the board strength is almost unchanged for resin contents as low as 6.0 per cent and there is no significant difference in the tensile stress or in the screw holding strength. With the exception of the 8 per cent resin boards made from flakes milled to pass a ½ inch screen, the thickness swelling is considered to be a little high but still within the BSS but the water absorption in all cases complies with the BSS.

Acacia cyanophylla

Table 4 gives the results of tests carried out on boards made from *Acacia cyanophylla*. The flakes used were milled through ½ inch screen and kept at constant width, 1.2 inches long and 0.024 inches thick. Comparisons were made between boards containing 10 per cent of the fines and those from which fines were excluded. Resin contents of 9.0, 8.0, 7.0, 6.0 and 5.0 per cent were used and 1.0 per cent (by weight) of wax was added to some of the boards containing 8.0 per cent of resin. The presence of

10.0 per cent of fines has practically no effect on the modulus of rupture of the particle boards, nor does the presence of fines appreciably affect the tensile stress or the screw holding properties. With resin contents as low as 5.0 per cent, the modulus of rupture, tensile stress and screw holding are all within the BS specification but both the water absorption and thickness swelling are excessive. With a resin content of 9.0 per cent, the thickness swelling is still too high and it is not until 1.0 per cent of wax together with 8.0 per cent of resin is used that the boards comply with the BS requirements in this respect.

On the whole, this species does not produce very good boards.

Quercus alnifolia

Table 5 shows the results of the tests carried out on boards made from *Quercus alnifolia* using flakes of dimensions which gave the best results with the other species and with and without the inclusion of fines. As will be seen from the table of results, it was not possible to produce a board from this species having a modulus of rupture which complied with the BSS unless the density was increased to 55 lb cu.ft. All the other test parameters are within or at the BSS but in general, it is considered that this species does not make good particle boards.

Alnus orientalis

Table 6 shows the results of tests carried out on boards made from *Alnus orientalis* using flake dimensions as with the previous species. In each case, with and without the inclusion of fines, the modulus of rupture considerably exceeds the value shown in the BS specification. The tensile stress and screw holding values are also well within specification but the water absorption and thickness swelling are in most cases, too high and many are not within the specification. The addition of 1.0 per cent of wax does however produce a board with 8 per cent of resin which fulfils the requirements of the BS in all respects. Again this species cannot on the whole be considered a good board making material.

Eucalypt species

Tables 7 and 8 show the results of tests carried out on boards made from milled flakes (½" screen) of *E. gomphocephala* and *E.camaldulensis* respectively. For these tests 10.0 per cent of fines were included. It will be seen that with only one exception, the values specified in British Standards for the modulus of rupture, tensile strength and screw holding, were exceeded for both species. Without the addition of wax, water absorption and thickness swelling figures with both species fail to meet BSS. As will be seen from the table, the addition of wax to 8 per cent resin boards brings both species (with one comparatively small exception) to within the BSS.

Mixture of species

Table 9 shows the results of tests carried out on particle boards made from a mixture of equal weights of *Pinus brutia, Pinus nigra, Acacia cyanophylla* and *Alnus orientalis.* It also shows the results of similar tests in which the timbers used were mixed together in the same proportionate weights as we were advised would be available for boardmaking in Cyprus – i.e. 80 : 5 : 5 : 1.

Eucalyptus gomphocephala and *Eucalyptus camaldulensis* were not included in either of these mixtures because apparently none of this timber is available in Cyprus for boardmaking at the present moment.

Quercus alnifolia was also excluded because with this timber only high density

particle boards comply with British Standards.

As will be seen from the table, both mixtures produced boards which fulfilled the BS in strength characteristics but the addition of wax was required so that they would pass the standard for thickness swelling.

GENERAL CONCLUSIONS

1. The object of this investigation was to evaluate these seven species of Cyprus timber for their potential usefulness for the production of particle board. Throughout, it has been assumed that the definition of useful boardmaking material is one which will make a 40 lb per cu.ft. board with 8 per cent of synthetic resin binder (with up to 1 per cent of wax if required) having properties which fulfil the relevant BSS. The many reasons for adopting these board parameters are partly technical but mainly economic. Very briefly, the density has been fixed by industrial, technical and economic practice in developed countries as the optimum compromise between unpressed mat thickness, strength (this is proportional to density) and customer attraction. Strength can be increased by using more resin but the binder is the most expensive single component of a board. Industrial experience in developed countries indicates that the 8 per cent level is the best compromise between cost and board strength. It must be said that there is no reason why these considerations should not be modified for the needs of a developing country but they have been used as a reference level for comparison purposes with these seven species.

2. With this in mind, it is considered that both *Pinus brutia* and *Pinus nigra* would be in general, extremely good materials for particle board manufacture. In many respects they are fully up to the quality of the softwoods traditionally used in developed countries.

3. Of the other species, *Acacia cyanophylla, Alnus orientalis* and both Eucalypt species are only fairly good boardmaking materials. Perhaps their worst failing is the tendency for boards made from them to be unduly affected by moisture.

4. *Quercus alnifolia* is the worst of the seven. On the whole its use alone for boardmaking cannot be recommended.

5. With the boards made from a mixture of species (with the exclusions referred to in the report) it would appear that the two pines are 'carrying' the other less suitable species. Nevertheless, these mixed species boards are acceptable and might prove useful for the production of cheaper and weaker core-boards destined for subsequent facing or lamination.

Tables

Table 1
Pinus brutia
Resin content 8.0 per cent: fines excluded

Flake dimensions ins. Width	Length	Thickness	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress Parpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent
0.75 – 1.50	0.6	0.008	39.9	2800	48	132	55
	0.8	0.016	41.7	2820	33	144	45
	1.2	0.024	41.5	3680	43	145	50
	1.6	0.032	41.8	3290	21	176	38
0.06 – 0.25	0.6	0.008	41.6	3450	97	212	40
(Through ½ in)	0.8	0.016	40.2	2720	70	212	40
screen	1.2	0.024	41.2	3340	134	228	53
	1.6	0.032	40.4	2700	88	216	26
0.06 – 0.12	0.6	0.008	40.8	3240	109	197	40
(Through ⅜ in)	0.8	0.016	40.8	2460	88	199	28
screen	1.2	0.024	40.4	3060	116	215	42
	1.6	0.032	40.3	1680	84	208	57
BS 2604: 1963				2000	50	80	75

Table 2
Pinus brutia
Flakes milled through ½ inch screen : fines excluded: resin content 8.0 per cent

Flake Dimensions ins. Length	Thickness	Density lb.cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress Perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent
0.6	0.008	41.6	3450	97	212	40
	0.016	40.5	2680	100	174	60
	0.024	41.9	3270	101	203	74
	0.032	39.5	2850	117	210	48
0.8	0.008	40.7	3240	80	170	31
	0.016	40.2	2720	70	212	40
	0.024	40.6	3390	152	207	61
	0.032	40.9	2610	140	210	54
1.2	0.008	41.2	2960	73	209	67
	0.016	41.9	3380	152	198	48
	0.024	41.2	3340	134	228	53
	0.032	40.5	3010	126	231	60
1.6	0.008	40.5	2860	100	186	44
	0.016	39.9	3230	133	186	50
	0.024	40.0	3110	139	188	53
	0.032	40.4	2700	88	216	36
BS 2604: 1963			2000	50	80	75

Table 3
Pinus nigra
Flake dimensions – length 1.2 in., thickness 0.024 in., milled through ½ in. and ¾ in. screen. Resin content varied: fines included and excluded.

Screen Size ins.	Resin content per cent	Fines content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water absorption per cent	Thickness swelling per cent
½	8.0	9.0	39.7	2250	152	183	51	11.6
		Nil	41.1	2240	107	186	57	12.2
	7.0	9.0	41.2	2060	113	190	64	17.5
		Nil	40.6	2215	152	197	55	12.3
	6.0	9.0	41.6	2200	173	177	66	16.3
		Nil	40.6	2105	144	150	66	22.4
¾	8.0	9.0	41.3	2140	95	191	53	13.4
		Nil	40.6	2100	108	214	51	13.9
	7.0	9.0	41.5	2415	139	185	59	15.0
		Nil	40.0	1980	117	176	54	14.7
	6.0	9.0	41.4	2380	172	172	60	15.8
		Nil	40.9	2180	173	189	50	15.7
BS 2604: 1963				2000	50	80	75	12.0

Table 4
Acacia cyanophylla
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.05 in. (through ½ in. screen)
Resin content varied: fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
9.0	10.0	40.2	3000	170	227	54	17.4
	Nil	40.6	3190	152	233	60	18.8
8.0	10.0	40.9	2840	103	210	61	18.5
	Nil	41.2	2650	117	204	70	24.5
7.0	10.0	40.4	2495	119	193	68	24.5
	Nil	40.7	2575	119	189	70	27.0
6.0	10.0	40.1	2400	140	193	66	23.0
	Nil	40.9	2755	139	190	68	26.5
5.0	10.0	40.4	2350	93	213	73	31.3
	Nil	41.6	2765	99	215	75	34.0
8.0 +1.0% wax	Nil	41.6	3300	147	246	22	12.1
BS. 2604: 1963			2000	50	80	75	12.0

Table 5
Quercus alnifolia
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.05 in. (through ½ in. screen)
Resin content varied: fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
10.0	10.0	41.2	1591	102	140	75	18.1
	Nil	40.0	1537	91	131	66	19.1
9.0	10.0	40.2	1532	74	151	71	18.7
	Nil	40.0	1676	95	145	64	17.2
8.0	10.0	40.5	1682	115	106	63	15.5
	Nil	41.1	1738	104	110	69	18.3
7.0	10.0	40.0	1414	119	95	65	16.9
	Nil	39.9	1404	100	108	74	21.8
6.0	10.0	39.2	1427	105	90	71	18.5
	Nil	40.5	1581	100	101	69	21.8
8.0	10.0	55.4	4158	189	384	38	19.8
8.0 + 1.0% wax	10.0	55.3	3688	184	300	34	22.8
BS. 2604: 1963			2000	50	80	75	12.0

Table 6
Alnus orientalis
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in. (through ½ in. screen). Resin content varied : wax included and excluded, fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	10.0	40.6	3073	138	226	68	23
	Nil	40.7	3169	158	226	76	24.4
7.0	10.0	41.2	2973	134	244	71	19.7
	Nil	40.6	3423	149	219	67	27.6
6.0	10.0	40.8	2905	113	219	73	30.1
	Nil	40.6	2901	101	203	82	34.7
8.0 + 1% wax	Nil	40.3	3399	143	239	19	9.7
3.0 + 1% wax	Nil	40.0	1873	62	112	10	6.6
BS 2604 : 1963			2000	50	80	75	12.0

Table 7
Eucalyptus gomphocephala
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in. (through ½ in. screen). Resin content varied : wax included and excluded, 10.0 per cent fines included.

Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	40.5	2095	81	143	77	21.7
7.0	40.8	2043	96	127	85	24.2
6.0	40.5	1771	64	119	95	30.1
8.0 + 1% wax	40.6	2501	116	161	39	17.5
BS 2604 : 1963		2000	50	80	75	12.0

Table 8
Eucalyptus camaldulensis
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 - 0.25 in., (through ½ in. screen). Resin content varied : 10.0 per cent fines included.

Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	41.2	2305	95	171	83	30.2
7.0	41.5	2387	92	163	85	32.5
6.0	41.3	2099	108	172	84	33.5
8.0 + 1% wax	40.5	2709	158	198	9	5.1
BS 2604 : 1963		2000	50	80	75	12.0

Table 9

Mixture of Species

Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in.(through ½ in. screen). Resin content 8.0 per cent, with and without wax : 10.0 per cent fines included.

Proportion* by weight of species	Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
1 : 1 : 1 : 1	8.0	41.2	3103	114	240	69	16.7
	8.0 + 1.0 wax	40.6	3073	141	237	9	4.1
80 : 5 : 5 : 1	8.0	40.7	2714	121	187	46	15.0
	8.0 + 1.0 wax	40.5	2464	95	183	13	5.3
BS 2604 : 1963			2000	50	80	75	12.0

**Pinus brutia : Pinus nigra : Acacia cyanophylla : Alnus orientalis*

Tropical Products Institute

50 INTERIM REPORT ON THE USE OF NON-WHEAT FLOURS IN BREADMAKING

DAV DENDY AND PA CLARKE

Errata p. 18 Plate 12 (b) delete :

(compare with 15a)

p. 24 Recipe 1 line 9 insert after Oxidant (Bromate) 75 :

p.p.m.

Tropical Products Institute,
56/62, Gray's Inn Road,
London, W.C.1.

G-50

Plate 1 Bakery at Industrial Development Department, Culham.

Interim Report on the Use of Non-Wheat Flours in Breadmaking

by

D A V Dendy and P A Clarke

SUMMARY

Experiments in the Test Bakery at the Industrial Development Department of TPI have led to the development of bread of good quality, made by mechanical dough development from a blend of 50 per cent wheat flour and 50 per cent cassava starch. This bread can be satisfactorily fortified with protein concentrates derived from, for example, coconut or soya, and it has also been made successfully in a commercial bakery. In this Report, full details are given of the work carried out during the evolution of suitable formulae and methods, and a brief note on future work is appended.

INTRODUCTION

This is the first six-monthly report on the work of the TPI Test Bakery at Culham (Plate 1). It is therefore worthwhile to relate briefly how the Bakery project came into being and to restate its aims and objectives.

Bread from wheat has been used in the Mediterranean Basin for many thousands of years. Frequently other materials - notably barley - have been used to dilute the wheat in times of scarcity.

As a food material, bread has several advantages:-

a. convenience - it is bought from a baker ready to eat;

b. balanced nutrients - it contains carbohydrate, protein (9 - 12 per cent dry weight), B vitamins and minerals;

c. keeping qualities - bread can be kept for several days;

d. it is a convenient accompaniment for high protein foods - such as cheese and meat.

Further, protein, vitamins, minerals, etc., can be added to the flour to give an enriched loaf of high dietary value. As a staple food, bread is superior to many both organoleptically and as a source of nourishment.

The habit of eating bread made from wheat spread throughout the world, and bread is now available in at least the larger towns of most developing countries. For climatic reasons, few of these countries grow wheat; imported wheat must be paid for with scarce foreign currency. It would clearly be to their economic advantage if imports of wheat could be reduced or even eliminated. FAO therefore instigated two projects:-

The first, at the Institut voor Graan, Meel en Brood, TNO, Wageningen, wa to develop a bread from non-wheat materials. These efforts have led to several publications, of which the paper "Bread from Non-wheat Flours", by Kim and de Ruiter (Food Technology, 22, 1968, 55) gives a very good summa of their achievements. Work on bread free of gluten (the extensible protein wheat that gives to bread its unique and much-desired texture) is not new, fo dietetic breads for use by patients suffering from coeliac disease have been developed, using various starches but omitting the gluten. Bread without gluten, whether made for coeliac patients or by the TNO process, has the cr and crumb structure of cake rather than bread and might not be considered organoleptically acceptable to those people already used to conventional brea as part of the diet.

The second project was begun at the British Arkady Company where J H Huls from FAO and a team from British Arkady, led by W Pringle, and backed b the laboratory facilities under A Williams, carried out preliminary studies o the partial replacement of wheat flour by other materials, using mechanical dough development rather than bulk fermentation for the ripening of the dough since it has been shown at the Flour Milling and Baking Research Association (Chorleywood) that weaker flours can be used for bread-making by this techni The composite flour made by blending strong wheat with a glutenless flour is, course, weaker for breadmaking purposes than an all-wheat bread flour. Th preliminary work of Hulse, Pringle and Williams is published in Cereal Scien Today, 14/3, 1969, 114, and is discussed later in this Report.

The TPI Test Bakery at Culham was established in March 1969 to continue the work already started by Hulse, Pringle and Williams, and to act as a service any developing country requiring advice, research or training facilities in the field of Bakery Technology.

Before starting experimental work, the objectives of the project were analyse and stated as follows:-

> The objective of the project "Use of Composite Flours in Breadmaking" i to evolve methods and formulae for making bread of acceptable quality fr "composite flours", these being blends of strong wheat flour with a non-wheat flour, fortified, if necessary, with protein-rich additives. The term "non-wheat flour" is used to include root starches and non-gluten-forming cereal flours. Initially samples of these materials would be obtained from developing countries and if these can be used to make a satisfactory bread, a baker will be sent abroad to carry out trials in local bakeries and to explore public reaction to the product.
>
> The economic benefits are considered to be, for developing countries alr using imported wheat flour, a considerable saving in foreign currency caused by lowering the imports of wheat flour, or a larger production of bread from the quantity already imported; for countries not yet importin wheat flour, and where malnutrition is endemic, gifts of wheat flour can be extended by dilution with local materials so that a larger section of the population will benefit.

A brief outline of the kind of work required was drawn up as a "Suggested Programme of Work", after discussion with British Arkady Company, the Flour Milling & Bakery Research Association (Chorleywood) and FAO. Very briefly, the programme of work consisted of three sections. Firstly, long-term studies of composite flour technology. These would include a thorough study of the Hulse, Pringle and Williams breads; where possible extending their work. Starch sources other than cassava would be studied, and protein supplements other than soya. Additives such as oxidants, emulsifiers, anti-staling and anti-mould agents would be studied for their effect on bread from composite flour. Secondly, work for the developing countries would be carried out at their request and it would be hoped that after a preliminary study of local starch or protein source at Culham, a TPI Bakery Technologist would work in the developing country under bilateral or UN Technical Assistance, demonstrating the making of bread from composite flour in local bakeries and exploring public reaction to the product. Thirdly, training: the TPI Bakery is able to give training in the techniques of bread-making, especially using composite flours. The optimum length of training period will, of course, depend on the trainees' knowledge and experience of bakery technology, and their particular objectives.

This programme of work has been followed as far as possible, revisions being undertaken in the light of work as it proceeds.

It is worthwhile at this stage to describe very briefly the methods used in Britain for breadmaking.

More than three-quarters of the bread eaten in Britain is made by mechanical dough development, also known as the "Chorleywood Bread Process". This was developed by scientists at the Flour Milling and Bakery Research Association, located at Chorleywood. The process eliminates the long (up to four hours) bulk fermentation required by traditional breadmaking methods. To effect the necessary ripening or development of the dough, a large amount of mechanical work is performed on the dough in a very short time (four minutes). Certain additives are necessary and more yeast must be used, but the expense of these is more than offset by the use of less labour, less space, greater standardisation and, above all, in the use of weaker flours. Since the adoption of the Chorleywood Bread Process in the late 1950's, the proportion of strong imported wheat, mostly Canadian, used in breadmaking, has been reduced from 65 per cent to 35 per cent, the rest being weak homegrown wheat which cannot tolerate a lengthy fermentation.

The TPI Test Bakery at Culham opened on 3.3.69 when Mr P A Clarke took up duty as Bakery Technologist. On September 3rd Mr A W James, formerly a Consultant Baker in Kenya, joined the team.

Equipment - The items of equipment used at the start of this period were:-

Tweedy 35 high-speed mixer for mechanical development of dough;
Europa Divider for dividing dough into pieces of equal weight;
Jacomolda for sheet moulding the dough;
Mason oven for baking bread. For the first month the lower deck of this oven was used as a proving cabinet for final-proof.
A gift of equipment from Oxford Co-operative Bakery was gratefully received: this included bakery trolleys, utensils and bowls.

Initially, intermediate proof was carried out at ambient temperature under cloths on the bench but later a pair of cabinets was purchased.

A proving cabinet for final proof was delivered in mid-March but the thermo control did not work and had to be replaced. Later the inside of this cabinet was rebuilt to allow a greater number of dough samples to be proved.

Towards the end of the period, apparatus for measuring oven spring and loaf volume was obtained, and a Morton Duplex dual speed mixer was brought into use. The TPI electrician has constructed a watt-hour meter so that the Mor mixer can now be used for the Chorleywood Bread Process on a half to one-a a-half kg. scale. The Morton mixer has been correlated with the Tweedy sc that valid results, suitable for scale up, are now obtained. This will prove extremely useful when working with small (e.g. air-mailed) samples.

During the first six-months, bread assessment, apart from oven spring and loaf height has been qualitative.

Materials

Strong Canadian wheat flour (Castle brand) is obtained from Russell & Baird contains 14.5 per cent protein (N x 5.70). For day-to-day control (Plate 2) a local baker's grade flour is used, obtained from Clark & Co. Ltd. of Wantage and containing 12.5 per cent protein. Australian flour is obtained from Russ Baird Ltd. and contains 10.5 per cent protein. Cassava starch is obtained fr Laing National Ltd. and is a high-grade Thailand tapioca.

Cassava/wheat Blends

The paper, "Mechanically Developed Doughs from Composite Flours", by Hulse, Pringle and Williams, describes some of the first attempts in recent years to make bread from blends of wheat flour with other starch materials; these were cassava, maize starch and 'millet/sorghum'. Soya and sometim fish protein concentrate (FPC) were used to bring the protein level to 12 per cent. Generally speaking, the composite flour contained 66 per cent of stron Canadian wheat flour (Castle). Hulse, Pringle and Williams only used mechanical dough development and in most of the experiments the flour was fortified with protein. Initially, this work was repeated and gradually chang were made to the recipe, described under various headings below (fat, yeast, oxidant, etc.)

It was decided to try to include the largest possible amount of cassava starch and bread was made using Recipe 2 (the recipes are at the end of this report), but varying the proportion of cassava from 0 to 60 per cent. The experiment was carried out with "Castle", "Clark's" and Australian flours. Even withou dilution the last gave a poor loaf. Plate 3 (a) to (e) shows bread containing 0, 10, 20, 30, and 40 per cent cassava with the Australian flour. For the other two the graphs (fig. 1.) of oven spring (the only physical property measurable at that time) against percentage were obtained. Plate 4 (a) to (e) shows bread containing 0, 10, 20, 30, and 40 per cent cassava with the Clark's flour. It is clearly no use diluting the Clark's flour to the extent of 50 per cent, the maximum to give an acceptable product being around 20 per cent; but the Castle flour will withstand 50 per cent dilution (Plate 5) and still give moderately good loaf with a fair oven spring.

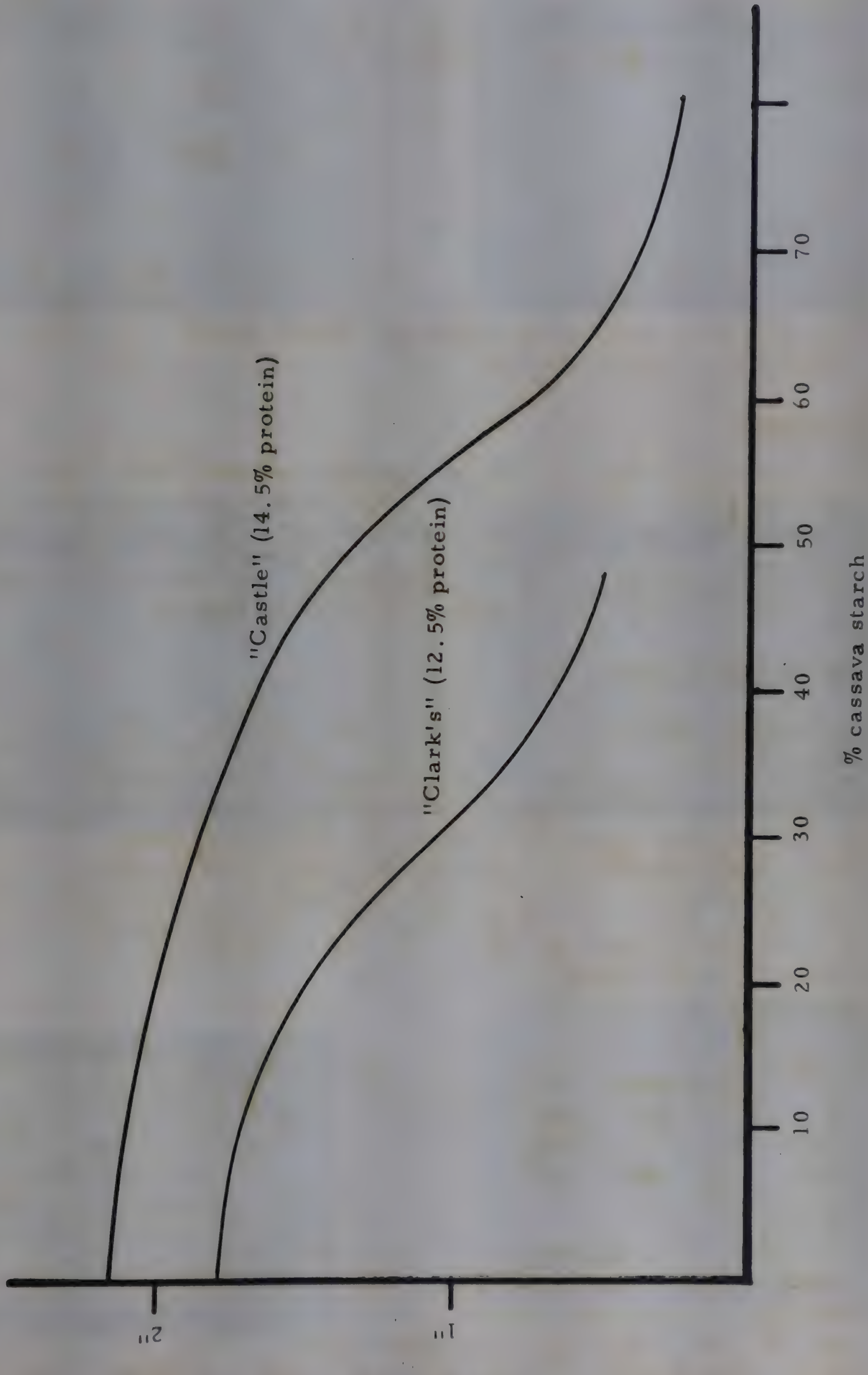
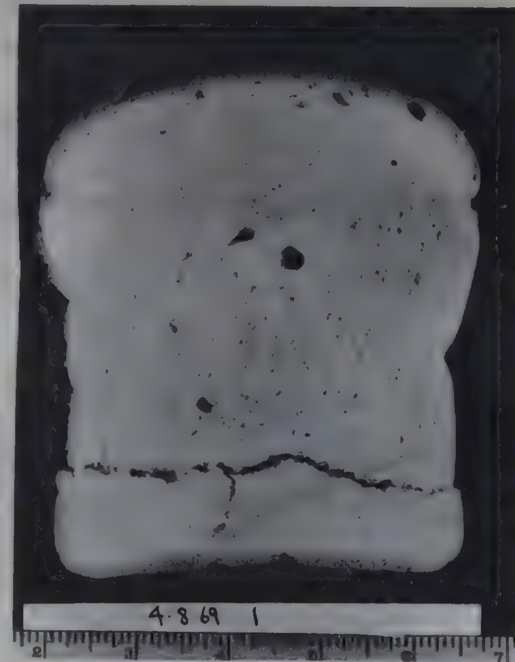
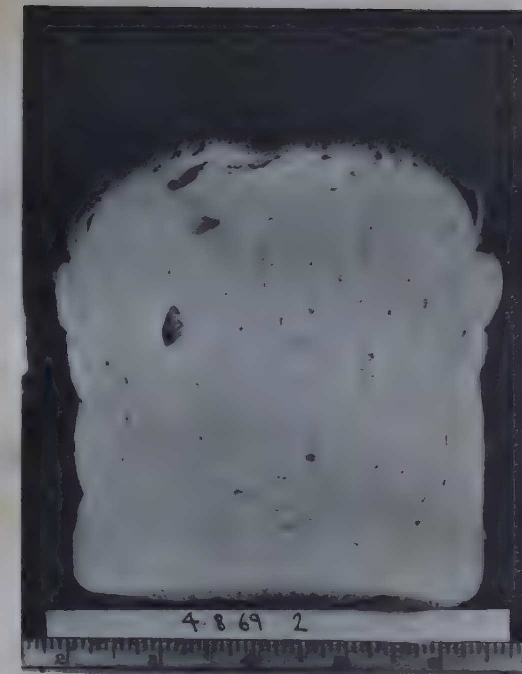

"Castle" (14.5% protein)
"Clark's" (12.5% protein)
oven-spring (inches)
2"
1"
10
20
30
40
50
60
70
% cassava starch

Figure 1

Plate 3 Recipe 2 Cassava starch/ Australian wheat flour.

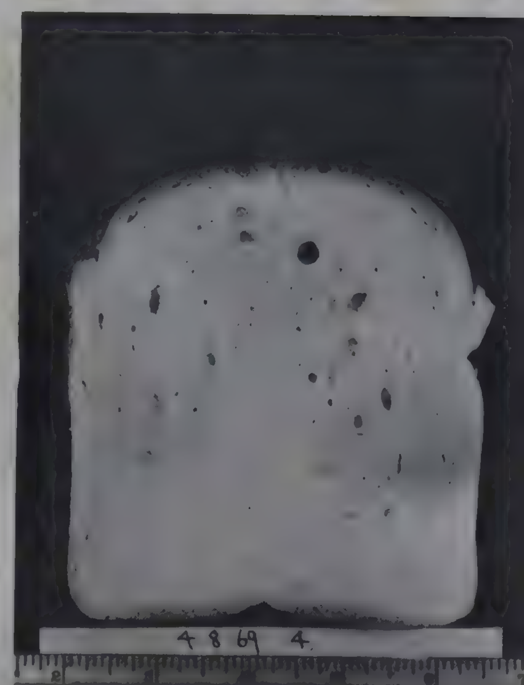


(a) 0% Cassava starch



(b) 10% Cassava starch

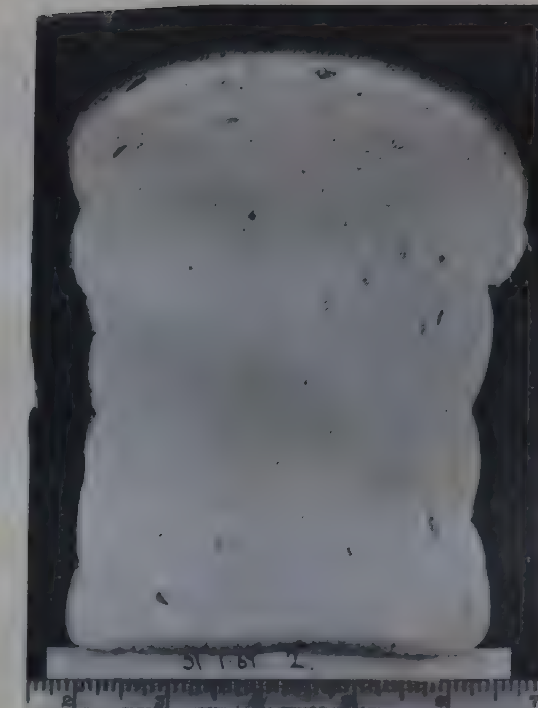
(c) 20% Cassava starch



(d) 30% Cassava starch

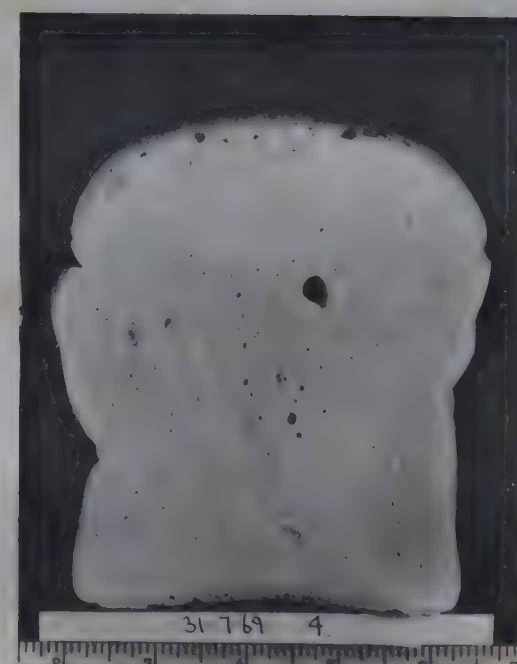
(e) 40% C

(a) 0% Cassava starch



(b) 10% Cassava starch

(c) 20% Cassava starch



(d) 30% Cassava starch

(e) 40% Cassava starch

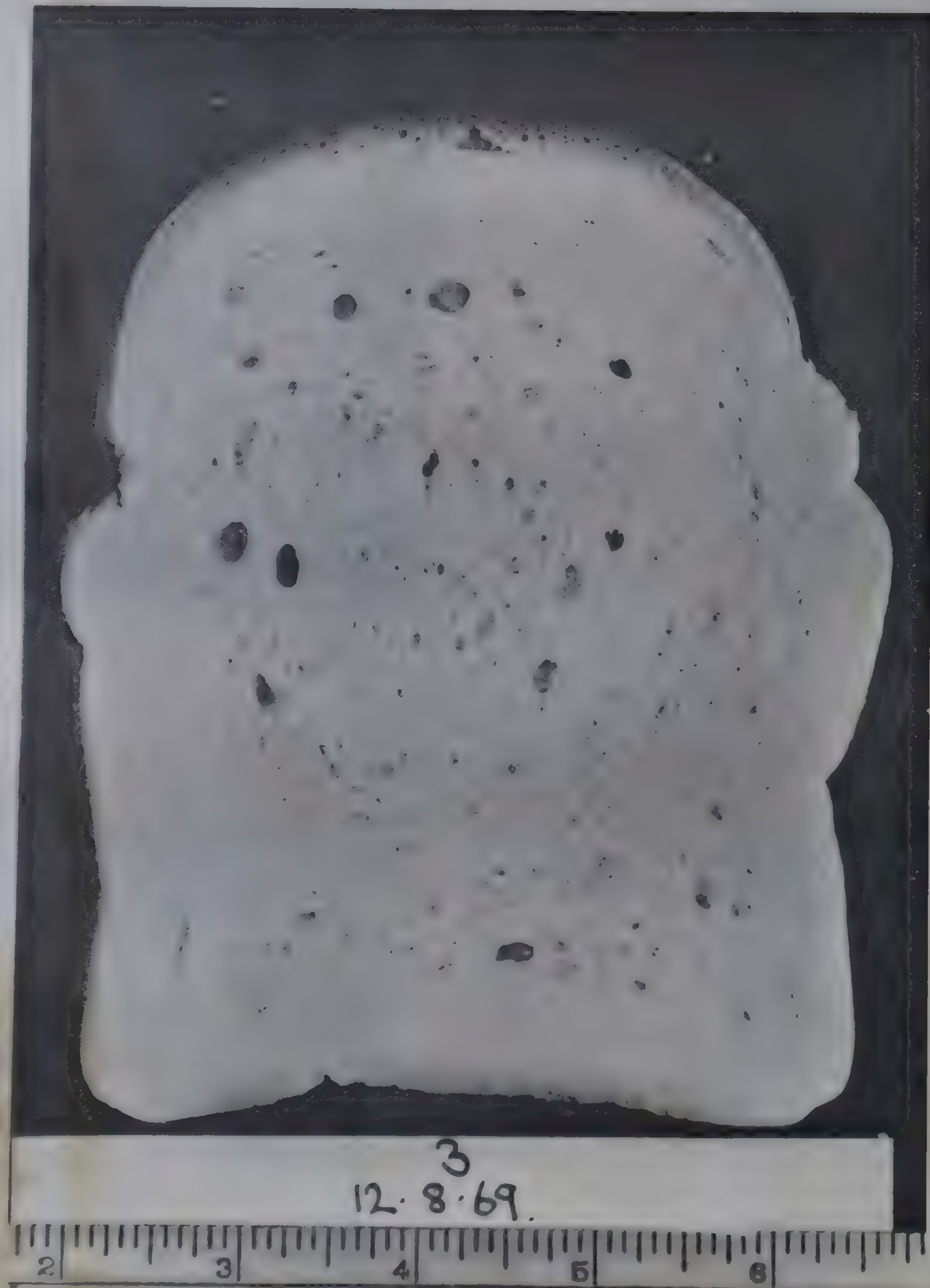
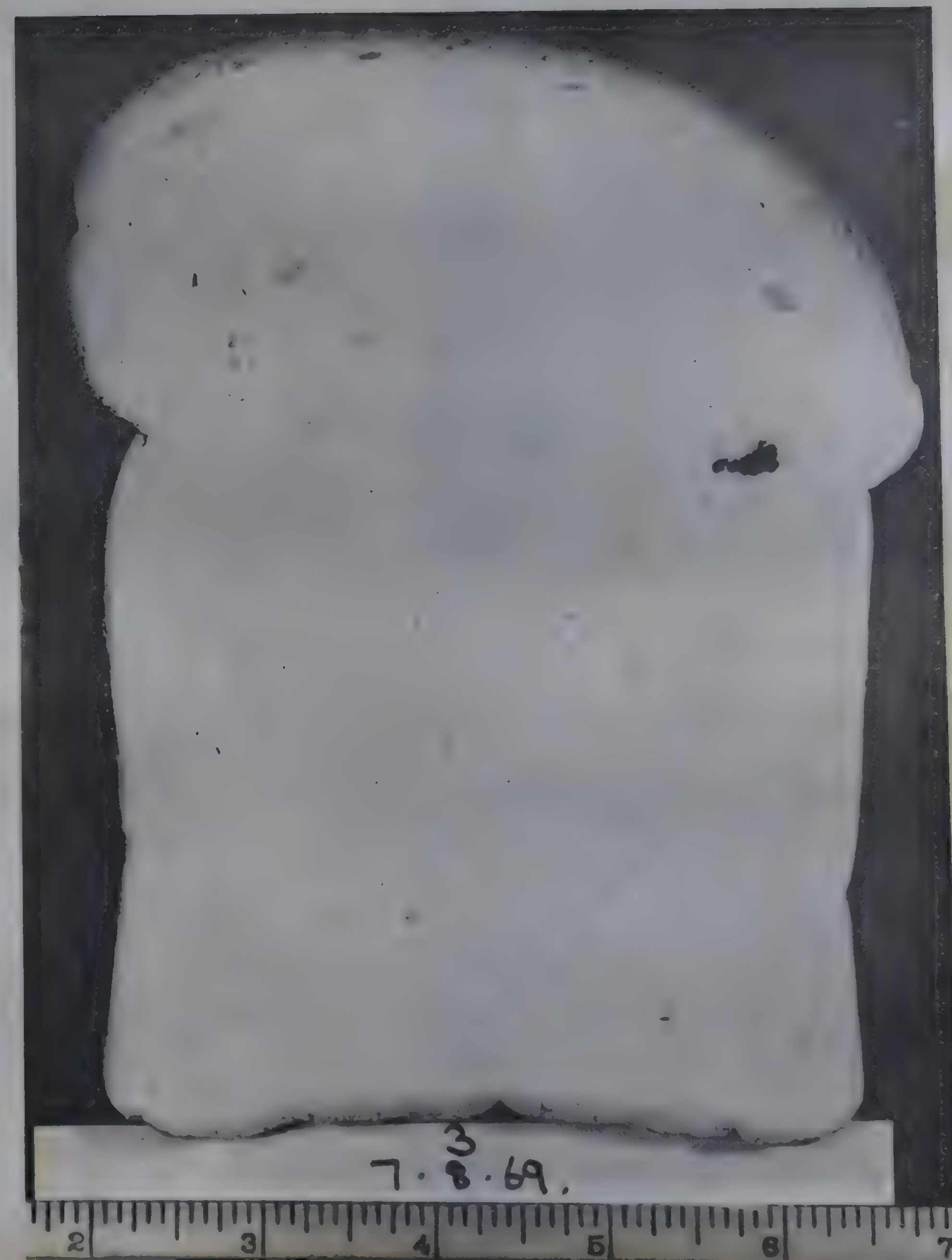


Plate 5 Recipe 2 50/50 Cassava starch/
strong Canadian Wheat flour ("Castle")



:ch/.

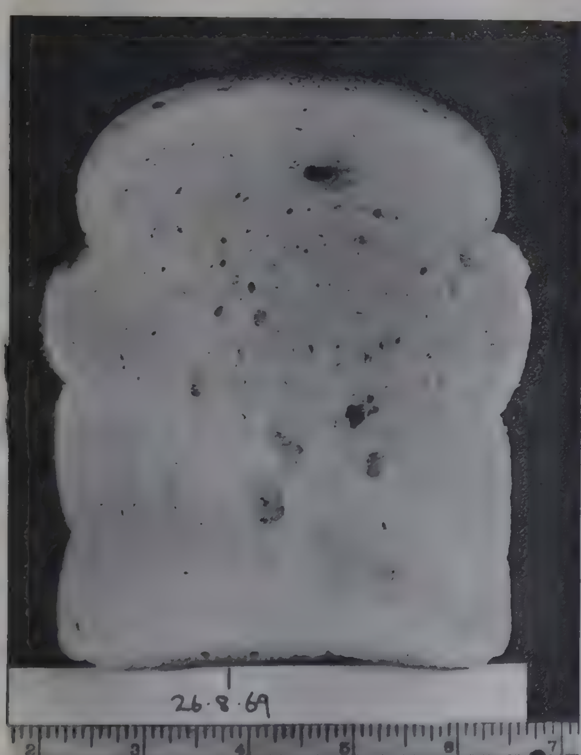
Plate 2 100% Wheat flour (Clark's"
baker's grade)

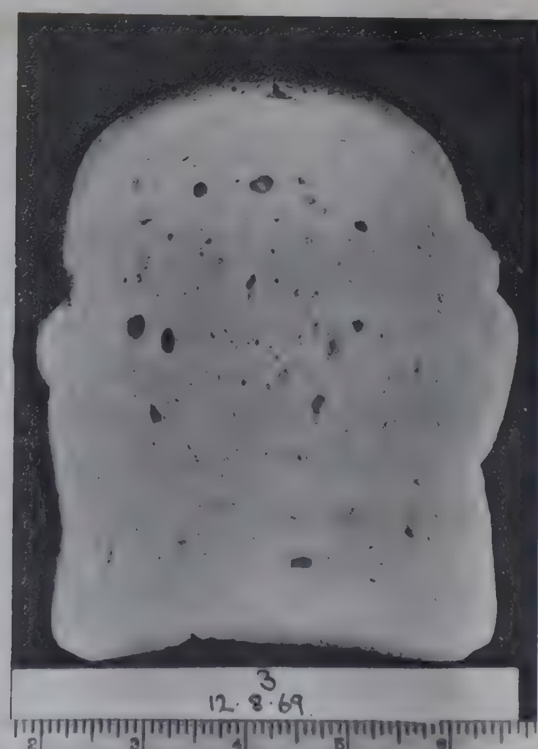
Plate 6 Recipe 3 50/50 Cassava starch/Castle wheat flour

(a) half usual amount of yeast "grown" for 1 hour

(b) usual amount of yeast

Plate 7 Comparison of "new delivery" with "old" dried yeast, using 50/50 "Castle" wheat flour/Cassava starch.

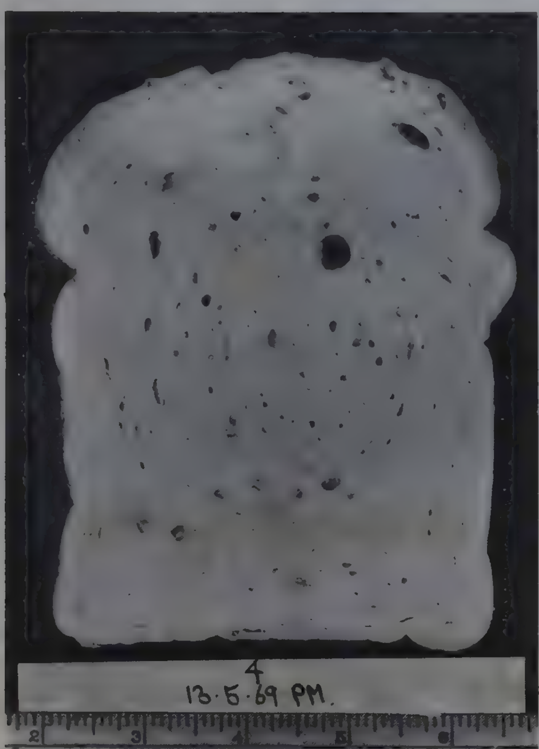




(a) New delivery yeast at. 1.3% flour weight

(b) Old yeast at 1.5% flour weight

Plate 8 Comparison of 2 oxidants.



(a) 200 ppm Potassium Bromate Recipe 1

(b) 150 ppm Ascorbic Acid Recip

Yeast

In the Hulse, Pringle and Williams work, compressed yeast was used. It is known that almost all developing countries use imported dried yeast since compressed yeast does not keep in the normal conditions of shipping. It was, therefore, decided that dried yeast should be used for bread-making experiments at TPI. A suitable level of reconstituted dried yeast was found that would give results equal to those obtained with compressed yeast. Approximately 40 per cent by weight of dried yeast compared to compressed yeast was needed, the yeast being reconstituted in the approved fashion by making a slurry with water to which sucrose has been added and leaving this brew to stand for fifteen minutes. Because of high yeast levels used in the Chorleywood bread process, tests were carried out to lessen the amount of yeast used. A reduction of 40 - 50 per cent in the initial yeast usage was achieved by aerobic yeast growth in a 10 per cent sucrose solution with small amounts of yeast nutrient. This suspension was allowed to ferment for one hour before adding to the dough. The dough contained 300 ppm flour weight of ammonium chloride as a yeast stimulant. The bread obtained (recipe 3) was equal to the control. Plate 6 shows bread from "grown" yeast (6a) compared with the control (6b).

It is interesting to note how important it is to check each new delivery of dried yeast. For the August delivery gassing results were abnormally good and a 10 - 15 per cent reduction in yeast usage could be achieved. Plate 7a shows bread from new delivery yeast compared with the control, 7b.

Oxidants

Two oxidants have been studied - potassium bromate and ascorbic acid, both separately and together. Initially samples of ascorbic acid gave poor results but a fresh sample was satisfactory and fresh supplies of ascorbic acid are now being stored in the refrigerator.

High bromate levels (200 ppm) gave excellent loaf volume (Plate 8a) with the Hulse, Pringle and Williams formula (Recipe 1). Efforts were made to lower the level of oxidants, but without success. However, substitution of glyceryl monostearate (GMS) by bread-fat (a high slip-point fat) led to good bread with the 50/50 recipe, using either bromate or ascorbic acid and for future work the level of 150 ppm ascorbic acid was chosen (Plate 8b) (in a large-scale production plant bakery, only half this quantity would be necessary and this would be the same as is sometimes used in commercial bread). Ascorbic acid is preferred to bromate as the latter leaves a residue of potassium bromide in the loaf. In spite of this, there is no limit set to the use of bromate in the United Kingdom (high levels are self-limiting through the physical effect on the loaf).

Fat

By using a high slip-point ($43^{\circ}C$) fat ("bread fat") at 0.7 - 1.4 per cent (flour/weight basis), instead of GMS, bread equal in volume and crumb texture to the Hulse, Pringle and Williams 50/50 loaf was obtained and this bread did not stale as rapidly (Recipe 2). Plate 9 (a) to (d) shows 50/50 bread made with 0, 0.35, 0.7, and 1.4 per cent fat. For comparison, qualitative staling rates

are as follows:-

"Small baker's" all wheat	4 days
Plant type all wheat (sliced and wrapped)	5 - 6 days
Hulse, Pringle and Williams 50/50 (GMS)	1 - $1\frac{1}{2}$ days
Hulse, Pringle and Williams 50/50 (fat)	2 days

In most tropical countries bread will probably go mouldy at an accelerated ra so that the use of fat will give a loaf of sufficiently low staling-rate (staling-r is inversely proportional to temperature, so that the elevated temperature of the tropical regions lowers the staling-rate of bread but, of course, will increase the drying out or, in humid regions, the rate of mould growth).

Sugar

When using dried yeast it was found that the yeast was slow in fermenting the diastatically produced maltose. On the addition of sucrose to the dough at 1 cent flour weight, good gassing results and a satisfactory loaf were obtained

Sucrose is also added to the yeast brew before the yeast is mixed with the flou Sugar (sucrose) is available very cheaply in many developing countries.

Work Input

Using a 50/50 formula the work input was varied from 6 to 13 watt hours per Kg. dough. Best results were obtained at 11 watt hour per Kg. which is the usual work level for commercial bread in the United Kingdom (i.e. 0.4 H.P/r lb. or 5 watt hrs/lb.)

Vacuum

For the 50/50 bread the best texture was obtained by using reduced pressure (400 mm) (Plate 10c), during the mechanical dough development in a range of experiments from 200 mm to ambient pressure. (Plate 10a)

Processing

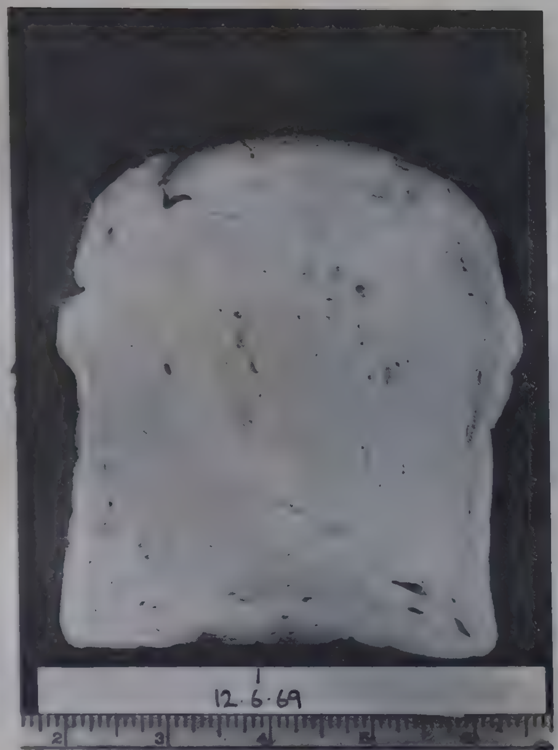
The texture of the 50/50 loaf could be further improved by using the 4 piece cross-panning technique (Plate 11c) rather than the one-piece technique (Plate 11a) usually used in Test Bakeries. Plate 11b shows the results of the two-piece twist technique. However, the one-piece technique will continue to be used as it gives a plainer loaf, easier to assess quantitatively.

Protein Supplementation

Samples of protein concentrates have been used to fortify the 50/50 loaf.

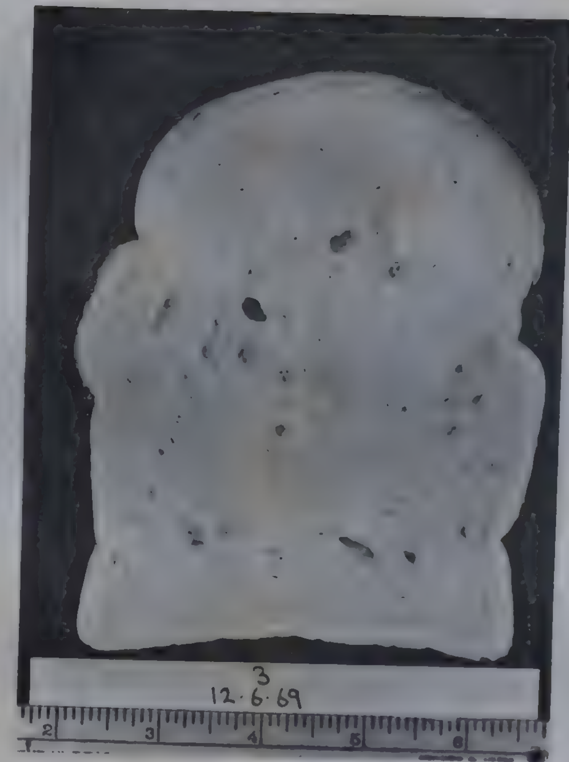
1. Cottonseed flour from EAIRO - Nairobi. 3 per cent cottonseed flour (at 100 per cent protein, N x 6.25) gave a loaf of extremely strong cottonsee flavour and poor texture and colour. Loaf volume was inferior.

Plate 9 Comparison of different percentages of fat in recipe 2, based on flour weight.



(a) 0%

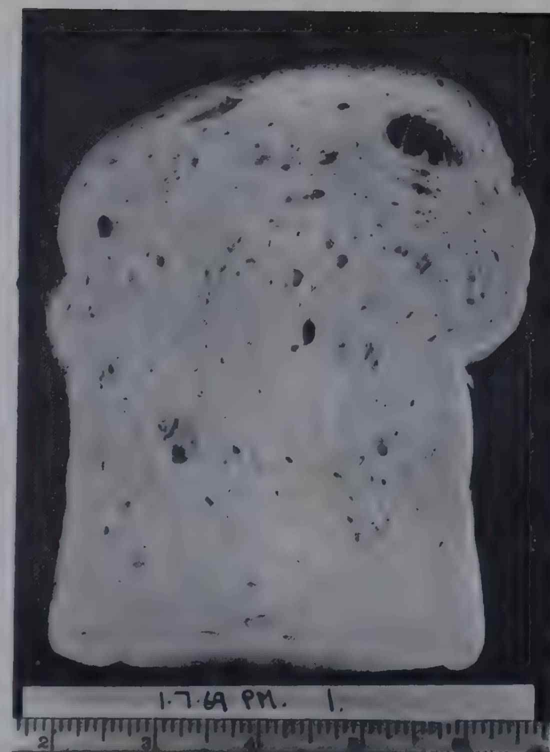
(b) 0.35%



(c) 0.7%

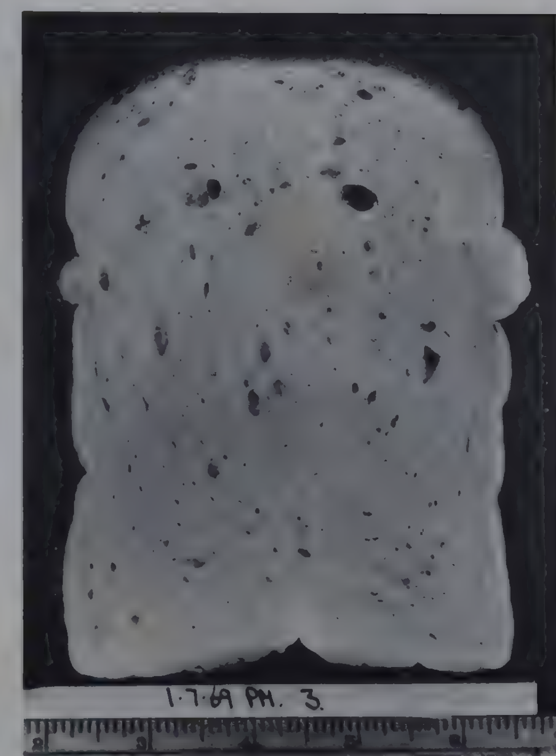
(d) 1.4%

Plate 10 Effect on texture of vacuum during mechanical dough development.



(a) Ambient

(b) 600 mm Hg



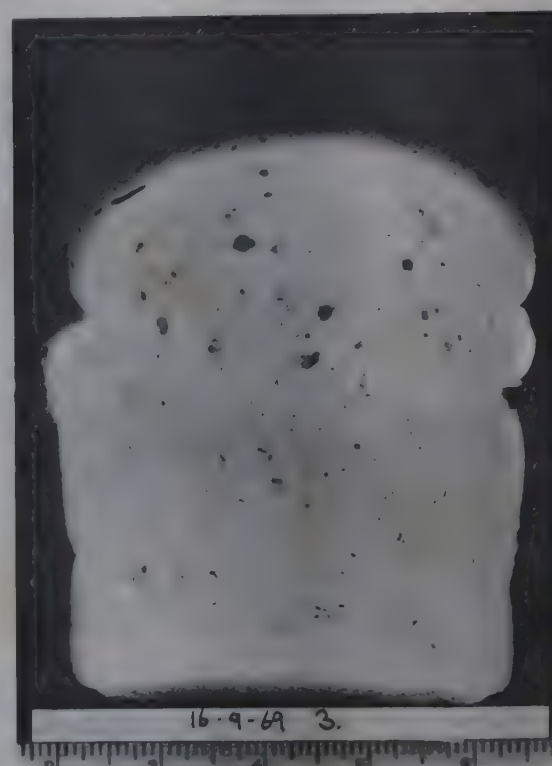
(c) 400 mm Hg

Plate 11 Effect on texture of using different processing techniques after sheet-moulding.

(a) 1-piece (b) 2-piece twist (c) 4-piece cross-panning

Plate 12 Protein supplementation, recipe 4

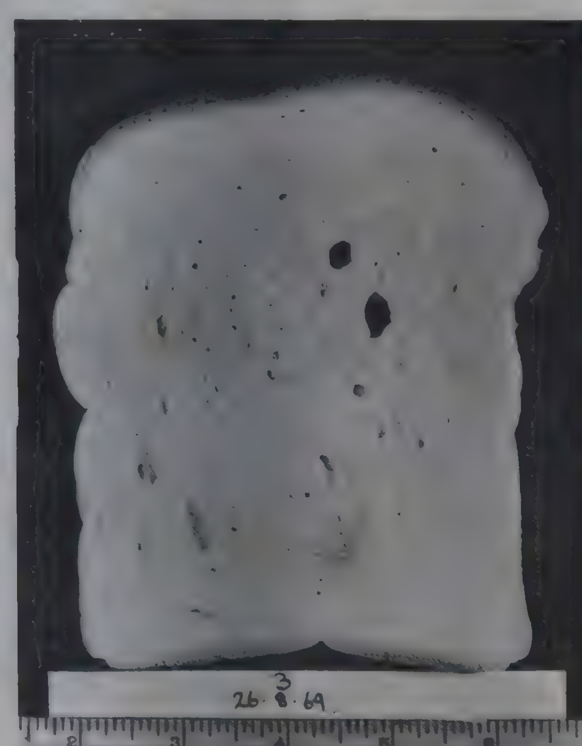
(a) 3% coconut protein



(b) 3% white coconut protein (compare with 15a)

Plate 13 Protein supplementation. Cassava starch/ wheat flour with soya.

(a) 50% cassava starch without soya



(b) 50% cassava starch with 6% defatted soya flour

2. Fish protein concentrate (88 per cent, N x 6.25) - 3 per cent, (as in 1) gave a grey crumb, very poor volume and a strong flavour of protein hydrolysate.

3. Coconut protein (80 per cent, N x 6.25) obtained from TPI Project 246 was used at 3 and 5 per cent levels. Each gave an excellent loaf. There was no adverse effect on crumb softness, loaf volume or flavour. The colour of the loaf was light brown but was not unpleasant. (Plate 12a). Recently "white" protein (N x 6.25 = 92 per cent) has been produced, and its use at 3 or 5 per cent levels gave similar results to the brown protein but also a white crumb (Plate 12b) (Recipe 4). Plates 12 (a) and (b) should be compared with 13a, of the 50/50 cassava/wheat loaf without supplementation.

4. Defatted Soya flour (N x 6.25 = 50 per cent) was added at 6 per cent flour weight to 50/50 cassava/wheat bread. The products possessed a slightly yellow crumb with very slight decrease in volume. Slight soya flavour was detectable but would not be unacceptable. (Plate 13b) (Plate 13a shows the 50/50 bread without soya).

Other Starch Sources

So far little work has been done on the use of materials other than cassava in diluting wheat flour.

Rice flour at 50 per cent level gave very poor results. A loaf containing 40 per cent rice flour to 60 per cent wheat flour gave a loaf of reasonable volume and excellent crumb softness.

Remembering that rice is still an expensive cereal in most countries, a blend of rice and cassava was used to dilute the wheat flour. A loaf containing 40 per cent cassava and 10 per cent rice had good volume and texture and excellent flavour and crumb softness. (Plate 14) (Recipe 5).

It might be possible for some developing countries to add a small amount of rice flour to a cassava/wheat blend to mollify the harshness of the crumb of the cassava/wheat loaf and to improve the flavour.

Plant Bakery Test

Having shown in the TPI Test Bakery that it is possible, on a small scale, to make bread containing only 50 per cent of wheat flour, it was considered desirable to make bread on a plant scale in a commercial bakery.

A local commercial bakery offered TPI the use, for a short period, of their plant. A small mixer, Tweedy 70, was used to prepare a dough using Recipe 6. The plant normally would use the Tweedy 280 but this scale of operation was considered too large and would have occupied the plant for a longer period. Due to a delay on the plant, the yeast fermentation was left for a period of 40 instead of 15 minutes and this, plus the lack of chilled water, led to a very lively, over-fermented, dough. The dough was processed through the normal plant so that the usual test bake procedure could not be followed. For example,

the sheet rollers of the moulder were set much closer than has been found desirable for doughs made from composite flours. Intermediate proof time (9 mins.) was high for such a lively dough, but could not be altered. The period of final proof (48 minutes at 45°C) and bake (36 minutes at 240°C) were also fixed by the plant. A four-piece bread was produced both as box (Plate 15a) and open type (Plate 15b). Oven temperature was too high for the open top bread and thus produced a burned crust.

Crumb texture was good, rather open and crustier than test bakery samples. Crumb softness, flavour and staling rate were similar but volume was slightly inferior.

It was concluded that with only very minor modifications to the plant bakery, bread equal to that produced in the test bakery would be obtainable from the recipe used.

<u>Visitors</u>

During the first six months of the bakery's existence, 26 visitors have come to the bakery, excluding commercial representatives and TPI personnel, and 13 these were from overseas, including trainees from Nigeria, and Nicaragua, each of whom spent a day working in the bakery.

<u>Future Work</u>

(a) Initial work was confined to mechanical development of dough using the Tweedy 35 machine and, latterly, for small samples, the Morton Duplex. Th advantages of mechanical dough development have been discussed frequently, notably for composite flours in the Hulse, Pringle and Williams paper. Howe the process can only be of benefit in countries where bread is made or will be made in plant bakeries, and where foreign exchange could be made available for purchasing suitable machinery.

Now that two bakery technologists are working in the Culham Test Bakery, mo emphasis can be given to other methods of bread-making, including bulk fermentation which is traditional in bread-eating countries, and perhaps, the use of "no-time doughs", which are developed by means other than mechanical work. If successful for composite flours, these other methods would be directly applicable in existing bakeries however small and under-mechanised, even though the high levels of dilution possible by mechanical dough developme are less likely.

(b) Equipment will soon be available for measuring loaf volume and staling rates and it is hoped later to purchase equipment for assessing the gelling properties of starches and rheological properties of doughs, and a suitable mil so that grain samples can be studied (at present, grain samples are being mill by the FMBRA at St. Albans).

(c) At present the TPI Test Bakery is testing flour from cassava, yam, banan sorghum, millet and wheat. Enquiries concerning these have been made by eight different developing countries.

Plate 14 Incorporation of rice flour (Recipe 5) 40% Cassava starch, 10% rice flour, 50% wheat flour ("Castle")

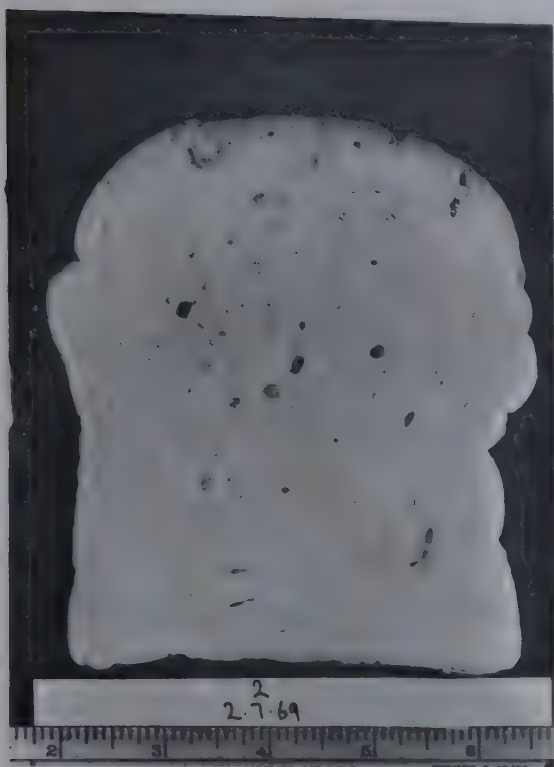
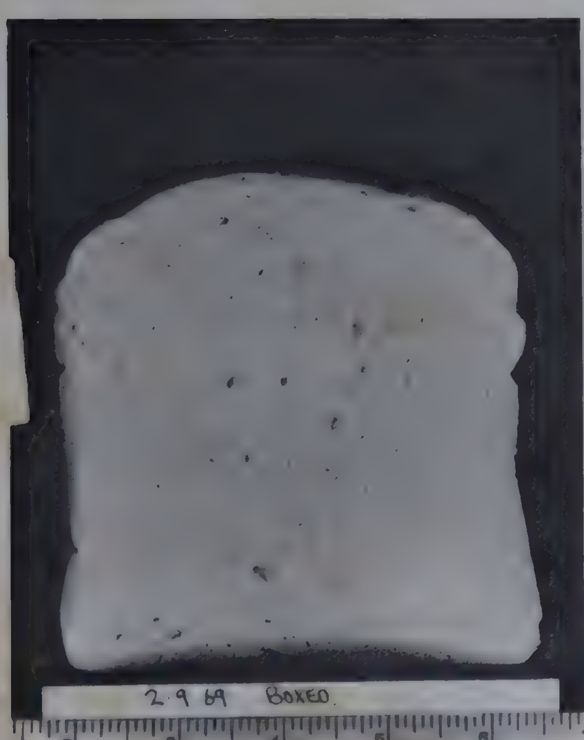


Plate 15 Commercial bakery production of bread from composite flour. Recipe 6 44% Cassava starch, 6% defatted soya flour, 50% wheat flour ("Castle")



(a) boxed loaf

(b) open tin loaf

(d) As well as extending our work on bread, as mentioned above, work will done on the use of non-wheat flour and protein supplements in the manufactu of other bakery products such as biscuits, doughnuts and cakes.

(e) More extensive training programmes are envisaged and staff of the Department will also be available to work in developing countries on technic and economic applications of the use of non-wheat flours in bakeries.

ACKNOWLEDGEMENTS

In this first report from the Culham Test Bakery, we wish to acknowledge the advice and help we have had from:-

Mr J H Hulse
Chief of Service,
Food and Agricultural Industries,
Agricultural Services Division,
FAO.

Dr G H Elton, Mr T H Collins and others
Flour Milling & Bakery Research Association,
Chorleywood.

Messrs W Pringle and D Tomlinson
British Arkady Co. Ltd.,
Manchester.

Mr Patrick O'Shea
General Manager,
Co-operative Wholesale Society Bakery,
Oxford.

Mr Kidman
Borough Polytechnic,
London.

30th September 1969

D A V Dendy
P A Clarke

RECIPES

Recipe 1 Hulse, Pringle & Williams 70/30 (Pringle, personal communica

	grams
Castle Flour	3500
Cassava Starch	1500
Salt	100
Yeast (compressed yeast equivalent)	150
Water (approx.)	3000
Oxidant (Bromate)	75
Diastatic Malt Flour	17.5
G M S (20% Emulsion in water)	100

Recipe 2

	grams
Castle wheat flour	2500
Cassava starch	2500
Salt	100
Yeast (dried)	65 (equivalent to 110-130 g. compressed)
Sucrose	70
Diastatic malt flour	20
Bread fat	35
Ascorbic Acid	150 ppm
Water (approx.)	2700

(N.B. ppm denotes parts per million of total composite flour weight)

Recipe 3 Yeast growth medium:
500 ml water @ 38°C
33 to 40 g. dried yeast
50 g. sucrose — Aerobic respiration for 1 hour
1 g. defatted soya flour
Trace fat (GMS)

Dough

	grams
Wheat flour	2500
Cassava starch	2500
Salt	100
Sucrose	50
Malt	20
Fat	35
Ascorbic Acid	150 ppm
Ammonium Chloride	300 ppm (yeast Stimulant)
Water (approx.)	2160

Control mix reconstitution:

500 ml water @ 38°C 65 g. yeast 20 g. sucrose	15 minutes (no air)

Dough as above except NH_4Cl.

<u>Recipe 4</u>

60/40 Bread		50/50 Bread
780	Wheat flour	650
480	Cassava Starch	650
26	Salt	26
20	Yeast	20
18	Sucrose	18
5	Malt	5
9	Fat	9
150 ppm	Ascorbic	150 ppm
770	Water	760
40	White Coconut Protein (90% protein content)	50

<u>Recipe 5</u>

	grams
Wheat flour	2500
Cassava starch	2000
Rice flour	500
Salt	100
Yeast	75
Sucrose	70
Malt	20
Fat	35
Ascorbic	150 ppm
Water	2690

Tropical Products Institute

Tropical Products Institute Report

G51 Selected bibliography on cassava (*Manihot esculenta* Crantz)

Jean S. Ingram

PREFATORY NOTE

The Tropical Products Institute has in preparation a number of interrelated reports on the production, processing and marketing of cassava and cassava products.

This bibliography is the first in the series.

The Tropical Products Institute is a British Government organisation which helps developing countries to derive greater benefit from their renewable resources.

It specializes in post-harvest problems and will be pleased to answer requests for information and advice. Reports such as this one are often written as the result of an enquiry.

Requests for further information should be addressed to:

The Director,
Tropical Products Institute,
56/62, Gray's Inn Road,
London W.C.1.

Introduction

The cassava plant *Manihot esculenta* Crantz, is known by many names, the most common of which are cassava in English speaking countries of Africa; manioc, manihot, mandioca and yuca in Latin America; tapioca in tropical Asia, and manioc in Francophone Africa. In European trade the terms 'manioc' and 'cassava' are usually applied to the dried (chips, roots, flour) or semi-processed root tubers and the products obtained by wet processing are called tapioca and tapioca starch. Moreover, in commercial practice, the terms starch and flour are very often used interchangeably. Botanically too there is some confusion. The valid taxon is *Manihot esculenta* Crantz, which is synonymous with the taxon *M. utilissima* Pohl. The latter, however, is still widely used, but as it is no longer valid, should now be discontinued.

Cassava is indigenous to tropical America and seems to have been in cultivation there for about four thousand years; it is now unknown in the wild state except as an escape. From South America, the plant has spread to tropical and sub-tropical regions all over the world, the main areas of culture being West Africa, East Africa, Brazil, India, Indonesia, Madagascar, Malaysia, Philippines and Thailand.

The plant is a perennial shrub which may reach a height of about 3 m. although the habit varies greatly between cultivars. The leaves are palmate and are often shed during dry periods with little apparent harm to the growth of the plant. The small apetalous flowers are borne in racemes near the ends of the branches, male and female flowers being borne on the same raceme. They are entomophilous. Female flowers are succeeded by three-seeded dehiscent capsules. The plant has a fibrous root system, but some of the roots develop into root tubers by process of secondary thickening. These tubers develop radially around the base of the plant and are the main economically useful part of the plant: they are used extensively as a starchy food in many tropical countries. The young leaves and shoots of cassava are rich in protein, vitamin and minerals. In some cassava growing regions they are consumed as a vegetable but their use is not very widespread.

Cassava thrives under various conditions of climates and soil types, and can withstand a certain period of drought. The relatively easy culture makes it a popular staple food crop in many parts of the world. However, it contains very little protein, around 1 per cent, and between 15 - 30 per cent of starch on a fresh-weight basis. It is thus essentially a carbohydrate food, and a cheap source of calories in the diet. So far as food production in the tropics is concerned, cassava is the most important single crop after rice. Production figures for 1967 are shown in the following table:

	1967 Production (thousands metric tons)
Latin America	32,783
Near East	130
Far East	19,323*
Africa	30,388
Oceania	115
World Total	82,739

(FAO Production Yearbook, 1968)

*Excludes Mainland China whose production is estimated to be about 10 million tons.

For complex reasons, there has been a rapid increase in cassava growing in rece
years. Nearly all the cassava in the world is produced by non-mechanised sub-sistence farmers to whom a most important factor is that cassava can produce more calories of food per unit input of labour than most other tropical crops. Naturally the plant benefits from good soil but it is extremely accommodating a produces reasonable yields even under adverse conditions. It is afflicted by few diseases, the most serious being mosaic virus (spread by a white fly, *Bemisia* spp.) which causes chlorosis and distortion of the leaves and may cause serious loss of yield or even death of young plants.

In addition to many food uses, dried cassava slices or chips are ground into coarse flour and used as a raw material for domestic and some industrial purpose e.g. animal feeding, starch, glucose and alcohol production. There is a sub-stantial international trade in cassava chips and pellets for compound animal feedingstuffs.

Considering the use of cassava for food and industrial products, there is good reason to believe that the crop will continue to increase in importance. In view of the worldwide interest in different aspects of the plant and its appli-cations, the following list of references has been compiled. This bibliography is by no means exhaustive as much of the material published on the crop consists of small notes of limited value, sometimes in literature difficult of access. It does, however, include most references of major value in the more accessible sources.

General

Affran, D.K. (1968) Cassava and its economic importance. *Ghana Fmr,* **12** (4), 172-178.

Alberto, J. (1957) A mandioca. Pt.I - Origem descr. e cultura. *Gazeta agric., Angola,* **1** (8), 295-300, 307; Pt.II - Doencas, pragas, animais selvagens. *ibid,* **2** (11), 504-506.

Alberto, J. (1958) A mandioca. Pt.III - Sues derivados, preparos e usos. *Gazeta agric., Angola,* **3** (3), 128-131. Pt.IV - Importancia economica da cultura. *ibid,* **3** (6) 266-272.

Angladette, A. (1949) La situation et l'avenir de la production du manioc dans les territoires d'outre mer de l'Union Française. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 63-68.

Angladette, A. (1949) Note sur la production du manioc. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 142-163.

Anon. (1949) Dahomey - Manioc des plantes féculentes tropicales. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 91-92.

Anon. (1949) Le manioc au Togo. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 100-106.

Anon. (1949) Note sur le manioc en Indochine. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 134-142.

Anon. (1961) Cassavas. *Farmer's Guide, Kingston, Jam. Rev. ed.,* 534-537.

Anon. (1962) The cassava industry in Jamaica. *Caribb. Agric.,* **1** (1), 34-41.

Anon. (1962) *Wealth of India, Raw Materials,* **6**, L-M, 286-297. *Coun. Sci. ind. Res., New Delhi.*

Bedu, P.	(1949)	Note sur le manioc au Cameroun. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 93-99.
Biokzeyl, K.R.F.	(1922)	*De Cassava.* 2nd Ed. Haarlem, Willi
Brand, D.D.	(1943)	Tapioca from a Brazilian root. *Agriculture in the Americas, U.S.D.A.*, **3** (5), 93-96.
Burkill, I.H.	(1935)	*A dictionary of the economic products the Malay Peninsula*, **2**, 1408-1420. London, Crown Agents.
Cerighelli, M., Cours, G.	(1950)	Les principales cultures des Comores. *Cah. colon. Supp. tech., Marseille*, Jan., (1), 9.
Childs, A.H.B.	(1961)	Cassava. *Min. Agric., Tanganyika, Bu* No. 15.
Corriols, M.	(1951)	Les cultures vivrières dans les territoires relevant du Secteur Soudanais de recherches agronomiques, Le manioc. *Agron. trop., Nogent*, **6** (7-8), 417-8.
Cours, G.	(1949)	Les études scientifiques sur le manioc la station agricole du Lac Alaotra. *Congrès du manioc et des plantes féculentes tropicales des territoires l'Union Française, Inst. colon. Marseille*, 124-131.
Cours, G.	(1949)	Note sur la culture et la selection du manioc a Madagascar. *Congrès du mani et des plantes féculentes tropicales d territoires de l'Union Française, Inst colon. Marseille*, 118-123.
Cours, G.	(1951)	Le manioc à Madagascar. *Agron. trop. Nogent.*, **6** (1-2), 76-77.
Cours, G. and Fritz, J.	(1960)	Le manioc. *Inst. de Rech. Agron. de Madagascar*, 23 pp. Doc. No. 1.
Doku, E.V.	(1969)	*Cassava in Ghana.* Ghana University Press, 44 pp.
Dufournet, R.	(1962)	Le manioc dans la province de Tulear (Madagascar), variétés locales synthès des essais variétaux. *Agron. trop., Paris*, **17** (11), 1015-1020.

Dufournet, R. et Goarin, P. (1957) Note sur la culture du manioc à Madagascar. *Riz Rizic. Cult. vivr. trop.*, **3** (1), 15-38.

Ekandem, M.J. (1962) Cassava in Nigeria, Part 1 - Eastern Nigeria. *Memo No. 42, Fedl Dep. agric. Res., Ibadan, Nigeria.*

Faurie, M. (1949) Etude des divers problèmes concernant le manioc à Madagascar. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 111-117.

Fritz, J. et Bohl, P. (1965) Le manioc à Madagascar. *Revue int. Prod. colon.*, **40** (425), Mars, 51-53.

Greenstreet, V.R. and Lambourne, J. (1933) Tapioca in Malaya. *Dep. Agric. Str. Settle. Fed. Malay States. Gen. Ser.* No. 13, pp.76.

Irvine, F.R. (1953) *A textbook of West African agriculture*, 111-118. London, Geoff. Cumberlege, Oxford University Press.

Johnston, B.F. (1958) *The staple food economies of western tropical Africa*, 106-112. California, Stanford Univ. Press.

Jones, W.O. (1959) *Manioc in Africa.* California, Stanford University Press. 315 pp.

Langlands, B.W. (1966) Cassava in Uganda, 1860-1920. *Uganda J.*, **30** (2), 211-218.

Massall, E., and Barrau, J. (1956) Food plants of the South Sea Islands. *S.P.C. tech. Pap.*, No. 94, 21-23.

Mendiola, N.B. (1931) Cassava growing and cassava starch manufacture. *Philipp. Agric.*, **20** (7), 447-476.

Mièges, J. and Lefort, M. (1949) Le manioc en Cote d'Ivoire. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 86-90.

Migvar, L. (1968) How to grow taros, yams, cassava and sweet potatoes. *Div. Agric., Dep. Resources Dev., Trust Territory Pacif. Is., Saipan, Mariana Is., Agric. Ext. Bull.*, No. 7, pp.32.

Mouton, J. (1949) Le manioc en Afrique Equatoriale Française. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 107-110.

Oyenuga, V.A. (1967) *Agriculture in Nigeria,* 166-171. *F.A.O. Rome.*

Purseglove, J.W. (1968) *Tropical crops. Dicotyledons,* **1**, 172-180. London, Longmans Green & Co. Ltd.

Pynaert, L. (1928) *Notes pratiques pour les colons agrico No. 11. Le manioc.* pp.80. *Min. colon., Bruxelles.*

Pynaert, L. (1951) *Le manioc.* 2nd Ed., pp.166. *Min. colon., Bruxelles.*

Rao, H.A.G. (1951) Cultivation of cassava and the prepara-tion of its products. *Mysore agric.* **27** (3), 57-69.

Rao, N.S. (1951) A short note on tapioca. *Mysore agric. J.,* **27** (3), 70-73.

St. Amand, R.D. de and Fritz, J. (1959) Les sols cultives en manioc dans la region de Moramanga. *Riz Rizic. Cult. vivr. trop.,* **5** (1), 49-53.

Silva, A. de F. (1964) A mandioca. *Gazeta Agric. Moçamb.,* **16** (179), 109-117.

Tapioca Enquiry Committee (1952) *Govt. Travancore - Cochin, India, Fina Rep.,* pp.125.

Tourneur, M. (1949) La culture du manioc. *Congrès du manioc et des plantes féculentes tropi-cales des territoires de l'Union Française, Inst. colon. Marseille,* 58-62.

Upton, M. (1966) Agriculture in Uboma. *Uboma. A socio-economic and nutritional survey of a rural community in eastern Nigeria; I Geogr. Union, The World Land Use Surve Occasional Pap.* No. 6, 83-104.

Afonja, B. (1968) Analyses of a uniformity trial on cassava. *Expl Agric.*, **4** (2), 135-141.

Albaquerque, M. de (1957) Some aspects of the social economic influence of cassava (*Manihot utilissima*) in Amazonia. (*Norte Agron.* 1957, **3** (3), 13-21), *Chem. Abstr.*, 1958, **52** (2), 1504.

Alagianagalingam, M.N., Ramakrishnan, K. (1969) Studies on a virus disease of tapioca (*Manihot esculenta* Crantz). I. Water relations and mineral metabolism. *Madras agric. J.*, **56** (6), 406-411.

Alagianagalingam, M.N. Ramakrishnan, K. (1970) Studies on a virus disease of tapioca (*Manihot esculenta* Crantz). II. Carbohydrate metabolism. *Madras agric. J.*, **57** (2), 55-62.

Alzona, O. (1935) Field tests of twenty varieties of cassava. Abstr. of thesis in *Philipp. Agric.*, **24** (1), 79-80.

Anantanarayanan, K.P. *et al* (1957) A note on the tapioca scale (*Aonidomytilus albus*, Cockerell) *Madras agric. J.*, **44** (7), 281-286.

Angladette, A. (1949) Note sur la production du manioc. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 142-163.

Anon. (1960) Results of cassava trials to date. *Chitedze Bull.*, No. 4, 1959. *Nyasald Fmr Forester*, **5** (2), 19-22.

Anon. (1968) Varietal improvement of four food crops in the Malagasy Republic. Rice - cassava - maize - sorghum. Present situation and future outlook. *The Abidjan Conference. Agricultural research priorities for economic development in Africa*, **2**, 162-174. *U.S. National Academy of Sciences.*

Anon. (1969) Le manioc (Fiche technique). *Cah. agric. Prat. Pays Chauds*, (4) 177-184. Supplement to *L'agron. Trop.*, **24** (10).

Anon. (1969) Control of weeds in cassava. *Notic. agric. Serv. Shell Agric.*, **5** (17), 65-67; *Fld Crop Abstr.*, 1969, **22** (4), 410.

Appan, S.G. Rogers, D.J. (1970) The closed gene pools of *Manihot* delimited by computer - aided taximetr methods, to aid utilization of the wil genetic wealth in cassava improvement programs. *Trop. Root and Tuber Crops Newsl.*, (3), 16-18.

Arraudeau, M. (1967) Cassava in the Malagasy Republic. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section III, 180-184.

Averre, C.W. (1967) Vascular streaking of stored cassava roots. *Proceedings of the Internatio Symposium of Tropical Root Crops, Trinidad*, **2**, Section IV, 31-35.

Beck, B.D.A. and Chant, S.R. (1958) Preliminary investigation on the effec of cassava mosaic virus on *Manihot utilissima* Pohl, in Nigeria: *Trop. Agric. Trin.*, **35** (1), 59-64.

Bolhuis, G.G. (1953) A survey of some attempts to breed cassava varieties with a high content protein in the roots. *Euphytica*, **2**, 107-112.

Bolhuis, G.G. (1967) Intra and interspecific crosses in the genus *Manihot*. *Proceedings of the International Symposium on Tropical Ro Crops, Trinidad*, **1**, Section I, 81-87.

Bouriquet, G. (1949) Pathologie du manioc dans les territoi français d'outre-mer. *Congrès du man et des plantes féculentes tropicales d territoires de l'Union Française, Inst colon. Marseille*, 73-75.

Brown, L.H. (1963) *A national cash crops policy for Kenya (Parts I and II)*, 120-122. *Min. agri Anim. Husbandry, Kenya.*

Chant, S.R. (1958) Studies on the transmission of cassava mosaic virus by *Bemisia* spp. (Aleyrodidae.) *Ann. appl. Biol.*, **46** (2), 210-215.

Chant, S.R. (1959) Note on the inactivation of mosaic vir in cassava (*Manihot utilissima* Pohl.)b heat treatment. *Emp. J. exp. Agric.*, **27** (105), 55-58.

Chant, S.R. and Marden, J.A. (1958) A method for the rapid propagation of cassava cuttings. *Trop. Agric., Trin.* **35** (3), 195-199.

Chant, S.R. and Beck, B.D.A.	(1959)	Effect of cassava mosaic virus on the anatomy of cassava leaves. *Trop. Agric., Trin.*, **36** (3), 231-236.
Cobley, L.S.	(1956)	*An introduction to the botany of tropical crops*, 174-177. London, Longmans, Green and Company.
Corriols, M.	(1951)	Les cultures vivrières dans les territoires relevant du Secteur Soudanais de recherches agronomiques. Le manioc. *Agron. trop., Nogent*, **6** (7-8), 417-418.
Cours, G.	(1949)	Les études scientifiques sur le manioc à la station agricole du Lac Alaotra. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 124-131.
Cours, G.	(1949)	Note sur la culture et la selection du manioc à Madagascar. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 118-123.
Cours, G., Fritz, J. and Ramahadimby, G.	(1963)	Phellodermic diagnosis of manioc. *Potash Rev.*, Subject 5, pp.2.
Cours-Darne, G.	(1968)	Improving cassava in Africa. *The Abidjan Conference. Agricultural research priorities for economic development in Africa*, **2**, 330-339. *U.S. National Academy of Sciences.*
Doku, E.V.	(1966)	Cultivated cassava varieties in Ghana. *Ghana J. Sci.*, **6** (3-4), 74-86.
Doku, E.V.	(1967)	Root crops in Ghana. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section III, 39-68.
Dufournet, R.	(1962)	Le manioc dans la province de Tulear (Madagascar), varietés locales synthèse des essais varietaux. *Agron. trop., Paris*, **17** (11), 1015-1020.
Ekandem, M.J.	(1962)	Cassava in Nigeria. Pt. I. Eastern Nigeria. *Memo No. 42 Fedl Dep. agric. Res. Ibadan, Nigeria* (not published).

Ekandem, M.J.	(1964)	Cassava investigations carried out in Northern Nigeria: 1958-62. *Memo No Fedl Dep. agric. Res., Ibadan, Nigeri*
Ekandem, M.J.	(1965)	Cassava investigations carried out in Northern Nigeria: 1958-62. *Samaru agric. Newsletter*, **7** (2), 22-29. (*Memo No. 55 Fedl Dep. agric. Res. Ibadan, Nigeria.*)
Ekandem, M.J., and Waitt, A.W.	(1965)	Effect of types of cutting on the yie of cassava. *Memo No. 59. Fedl Dep agric. Res. Ibadan, Nigeria.*
Huertas, A.S.	(1939-40)	A study of the yield of cassava as affected by the age of cuttings. *Philipp. Agric.*, **28** (9), 762-770.
Jacob, A., Uexkull, H. von	(1960)	*Fertiliser use. Nutrition and manur of tropical crops*, 151-157. Hannove Verlags für Ackerbrau mbH.
Jaubert, P.	(1953)	Manioc (diseases of leaves and stems) *Centre Recherches Agronomiques de Bam Bull.* No. 7, 38-39.
Jennings, D.L.	(1960)	Observations on virus diseases of cassava in resistant and susceptible varieties. I, Mosaic disease. *Emp. J. exp. Agric.*, **28** (109), 23-24.
Khen, C.S.	(1969)	Notes on the growing of cassava at Serdang. Paper read at *Malaysian Cr Diversification Conference, Kuala Lum* November. pp.9.
Kitajima, E.W. and Costa, A.S.	(1964)	Elongated particles found associated with cassava brown streak. *E. Afr. agric. For. J.*, **30** (1), 28-30.
Krochmal, A. and Cubero, J.	(1967)	A cassava insect. *Wld Crops*, **19** (6) 23.
Krochmal, A. and Samuels, G.	(1967)	The influence of NPK levels on the growth and tuber development of cassa in tanks. *Proceedings of the International Symposium on Tropical R Crops, Trinidad*, **1**, Section II, 97-10
Krochmal, A. and Samuels, G.	(1968)	Deficiency symptoms in nutrient pot experiments with cassava. *Ceiba*, **14** (1), 7-16.

Lambourne, J. (1927) A preliminary report on tapioca as a catch-crop with oil palms. *Malay. agric. J.*, **15** (4), 104-113.

Lambourne, J. (1937) Tapioca varietal trials. *Malay agric. J.*, **25** (3), 107-112.

Lambourne, J. (1937) Experiments on the economic maintenance of soil fertility under continuous cropping with tapioca. *Malay agric. J.*, **25** (4), 134-145.

Lulofs, R.B. (1969) A study of method and costs for commercial planting of tapioca in Kedah. Paper read at *Malaysian Crop Diversification Conference, Kuala Lumpur.* November. pp.18.

Magoon, M.L. (1967) Recent trends in cassava breeding in India. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section I, 100-117.

Magoon, M.L., Jos, J.S. Nair, S.G. (1969) A morphological, embryological and cytological study of male sterility in *Manihot esculenta* Crantz. *Trop. Root and Tuber Crop Newsl.*, (2), 10-14.

Magoon, M.L. Jos, J.S. Nair, S.G. (1970) Cytogenetics of induced polyploids of cassava. *Trop. Root and Tuber Crops Newsl.*, (3), 18-20.

Malavolta, E., Graner, E.A., Coury, T., Brasil Sobr, M.O.C., Pacheco, J.A.C. (1955) Studies on the mineral nutrition of cassava, (*Manihot utilissima* Pohl.) *Pl. physiol. Lancaster*, **30** (1), 81-82.

Mallamaire, A. (1949) Les insectes nuisibles au manicc en Afrique Noire. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 72-73.

Marassi, A. (1968) La manioca in Costa d'Avorio la sua importanta, negli ordinamente producttivi del paese. *Riv. agric. Subtrop. Trop.*, **62** (7-9), 201-227.

Mason, R.R. (1956) Cassava varieties in Fiji. *Fiji agric. J.*, **27** (3-4), 88-93.

Menon, M.R., and Raychaudhari, S.P. (1970) Cucumber - a herbaceous host of cassava mosaic virus. *Pl. disease Reporter, U.S.D.A.*, **54** (1), 34-35.

Mercado, T.	(1939-40)	A comparative study of two bud sport of cassava and their parent varietie *Philipp. Agric.*, **28** (4), 308-315.
Mièges, J.	(1957)	Essais culturaux sur le manioc. *J. Agric. trop. Bot. appl.*, **4** (9-10) 402-441.
Mièges, J. and Lefort, M.	(1949)	Le manioc en Cote d'Ivoire. *Congrè manioc et des plantes féculentes tropicales des territoires de l'Unio Française, Inst. colon. Marseille*, 86-90.
Molinyawe, C.D.	(1967)	Status of root crop research in the Philippines. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section III 69-83.
Montoya, L.A., Casseres, E.H., Hernandez, G., Mosqueda, R., Brambila, S., Tejada, I.	(1967)	Preliminary work on the problem of classifying manioc varieties. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section I, 89-99.
Nilakantan, K.S.	(1952)	Manures for tapioca crop. *Tapioca Enquiry Committee, Govt. Travencore-Cochin, India. Final Rep.*, Appendix 92-96.
Normanha, E.S. and Pereira, A.S.	(1950)	Aspectos agronomicos da cultura da mandioca. *Bragantia*, **10** (7), 179-
Normanha, E.S.	(1969)	Tõda mandioca tem veneno. *Cooperco* **26** (234), 24-25. *Trop. Abstr.*, 197 **25** (1), t.144, 40.
Okigbo, B.N.	(1966)	The use of covariance in the adjustm for a fertility gradient in a cassav pre-planting cultivations experiment *Niger. J. Sci.*, **1** (1), 55-64.
Pingale, S.V., Muthu, M., Sharangapani, M.V.	(1956)	Insect pests of stored tapioca chips and their control. *Bull. cent. Foo technol. Res. Inst., Mysore*, **5** (6), 134-136.
Purseglove, J.W.	(1968)	*Tropical Crops, Dicotyledons*, **1**, 17 London, Longmans, Green and Co.
Pushparajah, E., Yeok, T.S.	(1969)	Tapioca as an intercrop in rubber. Paper read at *Malaysian Crop Diversification Conference, Kuala Lumpur*, November. pp.10.

Pynaert, L. (1928) *Notes pratiques pour les colons agricoles. No. 11. Manioc. Min. colon., Bruxelles*, pp.76.

Richardson, H.L. (1960) Manuring of crops in the Far East. *Wld Crops*, **12** (5), 183-184.

Rodriguez, N.F., Sanchez de Bustamente, C.A., Tarabanoff, J. (1966) Algunos factores que influyen en la comportamiento del cultivo de mandioca en la Provincica de Misiones. *Revta Invest. Agropecuarias, B. Aires*, Series 2, **3** (11), 167-208.

Rogers, D.J. (1963) Studies of *Manihot esculenta* Crantz and related species. *Bull. Torrey bot. Club*, **90** (1), 43-54.

Rogers, D.J. (1965) Some botanical and ethnological considerations of *Manihot esculenta*. *Econ. Bot.*, **19** (4), 369-377.

Rogers, D.J. (1967) A computer-aided morphological classification of *Manihot esculenta* Crantz. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section I, 57-80.

Schmidt, N.C. and Pereira, A.S. (1968) Comportamento do cultivar 'Mantiqueira', e de outros, de mandioca, em solos da serie pinhao (terciario), no vale do paraiba, estado de Sao Paulo. *Bragantia*, **27** (22), 249-255.

Schwerín, K.H. (1970) Apuntes sobre la yuca y sus origenes. *Trop. Root and Tuber Crops Newsl.*, (3), 4-12 (English summary 10-11).

Silva, J.R. da and Schmidt, N.C. (1967) Probable resistance to lodging of cassava cv. IAC-7-127. *Bragantia*, **26**, Note 13, LXIII-LXV; *Fld Crop Abstr.*, 1969 **22** (4), 410.

Silva, J.R. da and Freire, E.S. (1968) Influencia da apliçãcao de adubos minerais nos sulcos de plantio, sobre os "stands" de culturas de mandioca. *Bragantia*, **27** (26), 291-300.

Silva, J.R. da and Freire, E.S. (1968) Efeito de doses crescentes de nitrogenio, fosforo e potassio sobre a producao de mandioca em solos de baixa e alta fertilidade. *Bragantia*, **27** (29), 357-364.

Silvestre, P.	(1968)	Research on root crops. *The Abidjan Conference. Agricultural research priorities for economic development in Africa*, **2**, 340-345. *U.S. National Academy of Sciences.*
Sivagami, R. and Rao, K.R.N.	(1967)	Control of the tapioca scale *A. albus* Ckll. *Madras agric. J.*, **54** (6), 325-327.
Spencer, R.	(1962)	A rapid method for estimating the leaf area of cassava (*Manihot utilissima* Pohl.), using linear measurements. *Trop. Agric. Trin.*, **39** (2), 147-152.
Tardieu, M., Fauche, J.	(1957)	Contribution à l'étude des techniques culturales chez le manioc. *Annales Centre de Recherches Agronomiques de Bambey au Senegal, Bull. Agron.* No. 18 (2nd Part) - 1958, 14-25.
Templeton, J.K.	(1969)	Identification and naming of tapioca varieties in West Malaysia. Paper read at *Malaysian Crop Diversification Conference, Kuala Lumpur*, November. pp.9.
Upton, M.	(1966)	Agriculture in Uboma. *Uboma. A socio-economic and nutritional survey of a rural community in Eastern Nigeria, Int. Geogr. Union; The World Land Use Survey Occasional Paper* No. 6, 96-97.
Urueta, E.J.	(1970)	*Mononychus planky*, a potential pest to *Manihot* in Columbia. *Trop. Root and Tuber Crops Newsl.*, (3), 14.
Waitt, A.J., Ekandem, M.J.	(1966)	A method for scoring leaf symptoms of cassava mosaic virus. *Memo No. 62, Fedl Dep. agric. Res., Ibadan, Nigeria*
Williams, C.N. Ghazali, S.M.	(1969)	Growth and productivity of tapioca *(Manihot utilissima)* I. Leaf characteristics and yield. *Expl Agric.*, **5** (3), 183-194.
Yong, C.W.	(1969)	The performance of tapioca, sweet potato and ginger on peat at the Federal Experiment Station, Jalan Kebun, Selangor. *Planter, Kuala Lumpur*, **45** (521), 445-

Chemical and nutrition studies, toxicity

Abeele, M. van den and Vandenput, R. (1952) Manioc. *Plantes amylacées. Centre d'information et de documentation du Congo Belge et du Ruanda-Urundi, Min. colon., Bruxelles*, 3-12.

Adriaens, E.L. (1951) Recherches sur l'alimentations des populations au Kwango. Manioc. *Bull. agric. Congo belge*, **42** (3), 476-484, 518-520.

Adriaens, E.L. and Hestermans-Medard, O. (1954) Remarques a propos de la composition chimique du manioc roui, non roui ou cuit a l'eau. *Bull. agric. Congo belge*, **45** (1), 1-24.

Akinrele, I.A. (1964) Fermentation of cassava. *J. Sci. Fd Agric.*, **15**, Sept., 589-594.

Akinrele, I.A. (1967) Nutrient enrichment of gari. *W. Afr. J. biol. appl. Chem.*, **10** (1), 19-23.

Alba, M.G. (1937) A study of different varieties of cassava for hog feeding purposes. *Philipp. Agric.*, **25** (9), 782-796.

Bailey, K.V. (1961) Rural nutrition studies in Indonesia. III. Epidemiology of hunger oedema in the cassava areas. *Trop. geogr. Med.*, **13** (4), 289-302.

Bailey, K.V. (1961) Rural nutrition studies in Indonesia. IV. Oedema in lactating women in the cassava areas. *Trop. geogr. Med.*, **13** (4), 303-315.

Bassir, O. (1964) Improving the level of nutrition. *W. Afr. J. biol. appl. Chem.*, **7** (3), 32-40.

Barrios, E.A. and Bressani, R. (1967) Composición quimica de la raíz y de la hoja de algunas variedades de yuca *Manihot*. *Turrialba*, **17** (3), 314-320.

Bissett, F.H., Clapp, R.C. *et al* (1969) Cyanogenesis in manioc: concerning lotaustralin. *Phytochem.*, **8** (11), 2235-2247.

Cedillo, V.G. (1952) Cassava rice or landang. *Philipp. Agric.*, **35** (8), 434-440.

Clerk, G.C. and Caurie, M. (1968) Biochemical changes caused by some *Aspergillus* species in root tuber of cassava (*Manihot esculenta* Crantz.) *Trop. Sci.*, **10** (3), 149-154.

Close, J., Adriaens, E.L., Moore, S., Bigwood, E.J. (1953) Composition en acides aminés d'hydrolysats de farine de manioc rou[illegible] varieté amère. *Bull. Sté. Chim. Biol.*, **35** (9), 985-992.

Collard, P. (1963) A species of *Cornybacterium* isolated from fermenting cassava roots. *J. appl. Bact.*, **26** (2), 115-116.

Dema, I.S. and Osama, M.D. (1966) The diet, food economics and health of Uboma people. *Uboma. A socio-economic and nutritional survey of a rural community in eastern Nigeria; Int. Geogr. Union, The World Land Use Survey, Occasional Pap.* No. 6, 51-69.

Etorma, S.B. (1936) Chemical studies on cassava products. I. The critical moisture-molding conte[nt] of cassava starch. *Philipp. J. Agric* 7 (4), 409-412.

Favier, J.C. (1969) Les amylacés du Cameroun. I. Étude d[e] la digestibilité *in vitro* de l'amidon de diverges plantes alimentaires du Sud-Cameroun. Influence des transfor[ma]tions technologiques sur l'amidon de manioc. *Centre O.R.S.T.O.M. de Yaoun[de] (Cameroun)*, June, Pt. I. 9-13. Repr. also *Inds. aliment. agric.*, **86** (1), 9-13.

Favier, J.C., Chevassus-Agnes, S., Gallon, G. (1969) Les amylacés du Cameroun. II. Les transformations technologiques du manioc. Leur influence sur la valeur nutritive. *Centre O.R.S.T.O.M. de Yaounde (Cameroun)*, June, Pt. II, 3-53

Floch, H. (1957) Sur la richesse exceptionelle on vitamin C de feuilles de plantes Guyanaises (manioc, yucca, agaves). *J. Agric. trop. Bot. appl.*, **4** (9-10), 385-391.

Furlong, J.R. (1942) Nigerian cassava starch. *Bull. Imp. Inst.*, **40** (4), 257-268.

Garros, M. (1949) Standardisation et conditionnement des maniocs sechés et note sur le conditio[n]nement du tapioca. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 68-72.

Ghosh, B.N. (1967) Recent developments in the manufacture of starch from cassava roots in Uganda. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **2**, Section VI, 37-47.

Gramacho, D. (1947) Chemical study of the cassava roots. *Anais. assoc. quim. Brazil*, **6**, 123-132 and *Chem. Abstr.*, 1950, **44**, March, 2606.

Greenstreet, V.R. (1928) Studies on tapioca. I. Sampling a standing crop. II. The coeruleo-molybdate method for determination of phosphates. *Malay. agric. J.*, **16** (3), 59-75.

Greenstreet, V.R. (1929) Studies on tapioca. III. Further notes on determination of phosphoric acid in tapioca material by coeruleo-molybdate method. *Malay. agric. J.*, **17** (7), 210-212.

Gusten, R. (1968) Studies in the staple food economy of Western Nigeria. *No. 30 in Afrika studies series from the Ife Inst. für Wirtschaftsforschung, München.* London, Hurst & Co.

Halliday, D., Qureshi, A.H., Broadbent, J.A. (1967) Investigations on the storage of gari. *Rep. Niger. Stored Prod. Res. Inst., Fedl Min. Tr., Nigeria, Tech. Rep.* No. 16, 131-141.

Hegarty, P.V.J. and Wadsworth, G.R. (1968) The amount of iron in processed cassava *(Manihot utilissima)*. *J. trop. Med. Hyg.*, **71** (2), 51-52.

Jeffers, H.F. and Haynes, P.H. (1967) A preliminary study of the nutritive value of some dehydrated tropical roots. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **2**, Section VI, 72-91.

Johnson, R.M. and Raymond, W.D. (1965) The chemical composition of some tropical food plants. IV. Manioc. *Trop. Sci.*, **7** (3), 109-115.

Kim, J.C. and Ruiter, D. de (1968) Bread from non-wheat flours. *Fd Technol.*, **22** (7), 55-66.

Krochmal, A. and Samuels, G. (1967) The influence of NPK levels on the growth and tuber development of cassava in tanks. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **1**, Section II, 97-102.

Kuppuswamy, S. (1962) Studies on the dehydration of tapioca. *Fd Sci., Mysore*, **11** (4), 99-100.

Leroy, A.M. and François, A. (1949) Les plantes féculentes tropicales dans l'alimentation des animaux. *Congrès manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 75-78.

Majumder, S.K., Pingale, S.V., Swaminathan, M. Subrahmanyan, V. (1956) Control of spoilage in fresh tapioca tubers. *Bull. cent. Fd technol. Res. Inst. Mysore*, **5** (5), 108-109.

Maner, J.N., Buitrago, J., Jimenez, I. (1967) Utilisation of yuca in swine feeding. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **2**, Section VI, 62-71.

Martiis, P. de (1969) Efecto de las adiciones de almidõn de yuca, harina y harina precocida de mai sobre la panificaciõn de harinas comerciales de trigo. *Revta Inst. Invest. tecnol., Bogota*, **11** (58), 9-18

Massall, E. and Barrau, J. (1956) Food plants of the South Sea Islands. *S.P.C. tech. Pap.*, No. 94, 21-23.

Mathur, M.L., Sampath, S.R., Ghosh, S.N. (1969) Studies on tapioca: Effect of 50 and 100 per cent replacement of oats by tapioca in the concentrate mixture of dairy cows. *Indian J. Dairy Sci.*, **22** (3), 193-199.

Mitchell, D.L. (1964) *Some properties of starches extracted from chemically treated dry cassava. Makerere Univ. Coll. Rep. to Uganda De Corporation*, pp.29.

Montgomery, R.D. (1969) Cyanogens. *Toxic constituents of pla foodstuffs*, 143-157. Ed. by I.E. Lie New York; London, Academic Press.

Murthy, H.B.N., Swaminathan, M., Subrahmanyan, V. (1954) Effects of partial replacement of rice in a rice diet by tapioca flour on the metabolism of nitrogen, calcium and phosphorus in adult human beings. *Br. J. Nutr.*, **8** (1), 11-16.

Nartey, F. (1968) Studies on cassava, *Manihot utilissima* Pohl - I. Cyanogenesis: The biosynthe of linamarin and lotaustralin in etiolated seedlings. *Phytochem.*, **7**, 1307-1312.

Nartey, F. (1969) Studies on cassava, *Manihot utilissima* Pohl - II. Biosynthesis of asparagine-^{14}C from ^{14}C-labelled hydrogen cyanide and its relations with cyanogenesis. *Physiologia Pl.*, **22**, 1085-1096.

Nicholls, L., Sinclair, M.M., Jelliffe, D.B. (1961) *Tropical nutrition and dietetics.* London, Baillière, Tindall & Cox.

Oke, O.L. (1966) Chemical studies on some Nigerian food-stuffs - Kpo kpogari (processed cassava). *Trop. Sci.*, **8** (1), 23-27.

Oke, O.L. (1966) The need for a new source of protein. *W. Afr. Pharm.*, **8** (6), 112-116.

Oke, O.L. (1967) The present state of nutrition in Nigeria. *Wld Rev. Nutr. Diet.*, **8**. 25-61.

Oke, O.L. (1968) Cassava as food in Nigeria. *Wld Rev. Nutr. Diet.*, **9**, 227-250.

Oke, O.L. (1969) The role of hydrocyanic acid in nutrition. *Wld Rev. Nutr. Diet.*, **11**, 170-198.

Oyenuga, V.A. (1959) *Nigeria's feedingstuffs, their composition and nutritive value.* Ibadan, University Press.

Oyenuga, V.A. and Amazigo, E.O. (1957) A note on hydrocyanic acid content of cassava. *W. Afr. J. biol. Chem.*, **1** (2), 39-43.

Oyenuga, V.A., and Opeke, L.K. (1957) The value of cassava rations for pork and bacon production. *W. Afr. J. biol. Chem.*, **1** (1), 3-14.

Pereira, A.S., Nery, J.P., Conagin, A. (1960) Teor de acido cinidrico na polpa des raizes dos aipins. *Bragantia*, **19** (17), 247-259.

Pereira, A.S. and Pinto, M.G. (1962) Determinacao de toxicidade da mandioca pelo paladar das raizes in natura. *Bragantia*, **21**, Pt. 2, Note 25.

Phillips, P.G. and Ladell, W.S. (1959) Nitrogen balance in Nigerians. *J. trop. Med. Hyg.*, **62** (8), 181-194.

Pingale, S.V., Muthu, M., Sharangapani, M.V. (1956) Insect pests of stored tapioca chips and their control. *Bull. cent. Fd technol. Res. Inst. Mysore*, **5** (6), 134-136.

Prawiranegara, D.D. and Hong, L.G. (1962) *Main nutrition problems in Indonesia Presented at the Far East Symposium on Nutrition, Saigon - Vietnam*, 1962, und the joint sponsorship *of the Governmen of Vietnam, Ministry of Health and the Inter-departmental Committee on Nutrit for National Defence of the Government the U.S.A.*

Rasper, V. (1969) Investigations on starches from major starch crops grown in Ghana.
I. - Hot paste viscosity and gel formi power. *J. Sci. Fd Agric.*, **20**, 165-17
II. - Swelling and solubility patterns amyloclastic susceptibility. *ibid*, **2** 642-646.

Raymond, W.D., Jojo, W., Nicodemus, Z. (1941) The nutritive value of some Tanganyika foods. II. Cassava. *E. Afr. agric. J.*, **6**, 154-159.

Reddy, S.K., Doraiswamy, T.R., Sankaran, A.N., Swaminathan, M., Subrahmanyan, V. (1954) Effects on the general health and nutritional status of children of part replacement of rice in a poor vegetari diet by tapioca flour. *Br. J. Nutr.*, **8** (1), 17-21.

Ribeiro, O. (1942) The acidity of grated manioc flour. *An. Assoc. quim. Brasil*, **1**, 264-269.

Rogers, D.J. (1959) Cassava leaf protein. *Econ. Bot.*, **13** 261-263.

Rogers, D.J. and Milner, M. (1963) Amino acid profile of manioc leaf protein in relation to nutritive value *Econ. Bot.*, **17**, 211-216.

Sinha, S.K. and Nair, T.V.R. (1968) Studies on the variability of cyanogen glucoside content in cassava tubers. *Indian J. agric. Sci.*, **38** (6), 958-963

Sreeramamurthy, V.V. (1945) Investigations on the nutritive value tapioca *(Manihot utilissima)*. *Indian med. Res.*, **33** (2), 229-238.

Subrahmanyan, V., Murthy, H.B.N., Swaminathan, M. (1954) Effects of partial replacement of rice wheat or ragi *(Eleusine coracana)* by tuber flours on the nutritive value of poor vegetarian diets. *Br. J. Nutr.*, **8** (1), 1-10.

Subramanyam, H. and Mathur, P.B. (1956) Effect of a fungicidal wax coating on the storage behaviour of tapioca roots. *Bull. cent. Food technol. Res. Inst., Mysore*, **5** (5), 110-111.

Terra, G.J.A. (1964) The significance of leaf vegetables, especially of cassava in tropical nutrition. *Trop. geogr. Med.*, **16** (2), 97-108.

Vignoli, L. and Cristau, B. (1949) Caracterès analytiques des "tapiocas". *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille*, 81-83.

Williams, A.O. and Osuntokun, B.O. (1969) Peripheral neuropathy in tropical (nutritional) ataxia in Nigeria. Light and electron microscopic study. *Archs Neurol., Chicago*, **21**, 475; *BIBRA Inform. Bull.*, 1970, **9** (4), 200-201.

Winton, A.L. and Winton, K.B. (1935) *The structure and composition of foods*, **2**, 84-87. New York, John Wiley & Sons, Inc. London, Chapman & Hall, Ltd.

Wood, T. (1965) The toxic and nutritional qualities of cassava. *W. Afr. Pharm.*, **7** (1), 2-4.

Medical, pharmacological studies

Abrol, Y.P.	(1967)	Studies on the biosynthesis of amygdal the cyanogenic glycoside of bitter almonds. (*Prunus amygdalus* Stokes). *Indian J. Biochem.* **4**, 54.
Adams, J.H., Blackwood, W., Wilson, J.	(1966)	Further clinical and pathological observations on Leber's optic atrophy. *Brain*, **39**, 15-26.
Bailey, K.V.	(1961)	Rural nutrition studies in Indonesia. III. Epidemiology of hunger oedema in the cassava areas. *Trop. geogr. Med.* **13**, (4), 289-302.
Bailey, K.V.	(1961)	Rural nutrition studies in Indonesia. IV. Oedema in lactating women in the cassava areas. *Trop. geogr. Med.*, **13** (4), 303-315.
Ekpechi, O.L., Dimitriadou, A. Fraser, R.	(1966)	Goitrogenic activity of cassava (A sta Nigerian food). *Nature, Lond.*, **210**, 1137-1138.
Hirano, A., Levine, S., Zimmerman H.M.	(1968)	Remyelination in the central nervous system after cyanide intoxication. *J. Neuropath. exp. Neurol.*, **27**, 234.
Katiyar, K.P. and Ferrer, W.F.	(1965)	Evaluacion del efecto del polvo de yuc en la dieta larval de la mosca del Mediterraneo, *Ceratitis capitata* Wied. (Effect of yucca flour in the diet of larvae of the Mediterranean fruit fly, *Ceratitis capitata* Wied.) *Turrialba*, **15**, 350-353. (English summary.)
Langman, M.J.S., Doll, R., Wilson, J.	(1966)	Plasma and salivary thiocyanate in gastric cancer. *J. Br. Soc. Gastroenterology - GUT*, **7**, 549-552.
Monekosso, G.L. and Wilson, J.	(1966)	Plasma thiocyanate and vitamin B_{12} in Nigerian patients with degenerative neurological disease. *Lancet*, May 14 1062-1064.
Montgomery, R.D.	(1964)	Observations on the cyanide content an toxicity of tropical pulses. *W. Indi med. J.*, **13**, (1), 1-11.
Montgomery, R.D.	(1969)	Cyanogens. *Toxic constituents of pla foodstuffs*, 143-157, Ed. by I.E. Liene New York; London, Academic Press.

Osuntokun, B.O. (1968) An ataxic neuropathy in Nigeria - A clinical, biochemical and electrophysiological study. *Brain*, **91**, Pt. II, 215-248.

Osuntokun, B.O., Monekosso, G.L., Wilson, J. (1969) Relationship of a degenerative tropical neuropathy to diet: Report of a field survey. *Br. med. J.*, 1st Mar., 547-550.

Prawiranegara, D.D. and Hong, L.G. (1962) *Main nutrition problems in Indonesia* Presented at the *Far East Symposium on Nutrition, Saigon - Vietnam*, 1962, under the joint sponsorship of the *Government of Vietnam, Ministry of Health and the Interdepartmental Committee on Nutrition for National Defence of the Government of the U.S.A.*

Razafimahery, R. (1953-54) Glucosides cyanogenetiques pois du cap, manioc et 'Bononoka'. *Bull. de l'Acad. Malgache (New Series)*, **31-32**, 4-77.

Schubert, J. and Brill, W.A. (1968) Antagonism of experimental cyanide toxicity in relation to the *in vivo* activity of cytochrome oxidase. *J. Pharm. exp. Ther.*, **162**, 352.

Valencia, R. and Raibaud, P. (1968) Influence des conditions de culture sur la production de cobalamines par les bacteries de la flore intestinale du rat et sur leur fermentation. *Ann. Nutr. Alim.*, **22**, (1), 77-81.

Williams, A.O. and Osuntokun, B.O. (1969) Peripheral neuropathy in tropical (nutritional) ataxia in Nigeria. Light and electron microscopic study. *Archs Neurol., Chicago*, **21**, 475; *BIBRA Inform. Bull.*, 1970, **9** (4), 200-201.

Wilson, J. (1965) Leber's hereditary optic atrophy: A possible defect of cyanide metabolism. *Clin. Sci.*, **29**, 505-515.

Wilson, J. and Matthews, D.M. (1966) Metabolic inter-relationships between cyanide, thiocyanate and vitamin B_{12} in smokers and non-smokers. *Clin. Sci.*, **31**, 1-7.

Wood, T. (1965) The toxic and nutritional qualities of cassava. *W. Afr. Pharm.*, **7**, (1), 2-4.

Food, processing, machinery

Adeyinka, O. and Akran, C.D.	(1964)	Improvements on the 1 ton/day gari pl *Fedl Inst. Ind. Res. Niger., Res. Rep.* No. 29, pp.14.
Affran, D.K.	(1968)	Cassava and its economic importance. *Ghana Fmr,* **12** (4), 172-178.
Akinrele, I.A., Cooke, A.S. and Holgate, R.A.	(1962)	The manufacture of gari from cassava i Nigeria. *Proc. 1st Int. Congress Fd Sci. Technol.,* **4**, 633-644.
Akinrele, I.A.	(1965)	The water relations of some processed Nigerian foods. *Fedl Inst. Ind. Res. Niger., Res. Rep.* No. 33, pp.9.
Anderson, G.W.	(1944)	Notes on cassava preparation in North Kavirondo and Samia. *E. Afr. agric.* **10**, Oct., 111-112.
Anon.	(1943)	The preservation of manioc. *Dep. Agric., Ceylon Leafl.* No. 202, *Fd Prod Leafl.* No. 22, pp.5.
Bains, G.S., Reddy, S.K. Bhatia, D.S., Subrahmanyan, V.	(1952)	Investigations on the utilization of tapioca flour for chapatis, pooris and vermicelli. *Bull. cent. Food technol Res. Inst., Mysore,* **2**, 38-42.
Balu, V. and Parpia, H.A.B.	(1958)	*Tapioca macaroni goes to the people. Cent. Food technol. Res. Inst., Mysore Fd Sci. Extension Serv. Bull.* No. 1, pp.45.
Burton, L.V.	(1929)	Continuous process of (tapioca) manufacture. *Fd Industries, U.S.A.,* **1** (11), 491-494.
Cedillo, V.G.	(1952)	Cassava rice or landang. *Philipp. Agric.,* **35** (8), 434-440.
Collard, P. and Levi, S.	(1959)	A two-stage fermentation of cassava. *Nature, Lond.,* **183**, Feb. 28, 620-621.
Cruz. S.R., Palencia, P.L., Roque, B.H., Ozaeta, R.	(1959)	Mechanical cassava-peeling machine. *Araneta J. Agric.,* **6** (3), 184-205.

Dole, G.E. (1956) Techniques for preparing manioc flour as a key to culture history in tropical America. *Men and cultures. Selected Papers of the Fifth Int. Congress of Anthropological and Ethnological Sciences*, 241-248. Ed. by A.F.C. Wallace. Philadelphia, Univ. of Pennsylvania Press. London, Bombay, Karachi, Oxford Univ. Press.

Ekandem, M.J. (1961) Preparation of cassava in the human diet of Nigeria. *Fedl Dep. Agric. Res., Ibadan, Niger.*, Memo No. 29, pp.8.

Ghosh, B.N. (1967) Heat and air-flow characteristics in drying root crops. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **2**, Section VI, 1-27.

Hachero, L. (1957) A cottage cassava slicer. *Philipp. J. Agric.*, **22** (1-4), 81-88.

Hagen, V.W. von (1949) The bitter cassava eaters. *Nat. Hist., N.Y.*, **58** (3), 120-124.

Hartley, K.T. (1942) The production of cassava starch as a Nigerian village industry. *Bull, Imp. Inst.*, **40** (4), 268-271.

Holleman, L.W.J. (1950) *Java tapioca, its manufacture, grading and use. Organisation for Sci. Res. (Indonesia) Publ.* No. 22, *Djakarta*, pp.14.

Holleman, L.W.J. and Aten, A. (1956) *Processing of cassava and cassava products in rural industries. Agric. Dev. Pap., F.A.O.*, No. 54, pp.115.

Jarmai, S. (1968) A new fast method for the production of Kokonte. *Ghana J. agric. Sci.*, **1**, 59-63.

Johnston, B.F. (1958) *The staple food economies of western tropical Africa.* California, Stanford Univ. Press.

Kim, J.C. and Ruiter, D. de (1968) Bread from non-wheat flours. *Fd Technol.*, **22** (7), 55-66.

Krochmal, A. and Kilbride, B. (1966) An inexpensive laboratory method for cassava starch extraction. *J. agric. Univ. P. Rico*, **50** (3), 252-253.

Kuppuswamy, S. (1962) Studies on the dehydration of tapioca *Fd Sci.*, **11** (4), 99-100.

Lavigne, R. (1966) Etude sur séchage du manioc. *Bull. Madagascar*, **16** (240), 442-466.

Levi, S.S. and Oruche, C.B. (1958) Some inexpensive improvements in vill scale gari making. *Fedl Inst. Ind. Res., Niger., Res. Rep.* No. 2, pp.9.

Massall, E. and Barrau, J. (1956) Food plants of the South Sea Islands. *S.P.C. tech. Pap.*, No. 94, 21-23.

Mendiola, N.B. (1931) Cassava growing and cassava starch manufacture. *Philipp. Agric.*, **20** (7 447-476.

Mercado, T. (1939-40) Construction and improvement of cassa graters in the College of Agriculture *Philipp. Agric.*, **28** (2), 158-161.

Montemayor, Z. (1929) A promising cassava grater for the fa *Philipp. Agric.*, **17** (10), 593-597.

Nijholt, J.A. (1964) *Report of the survey of cassava production and processing in Ceylon. F.A.O.*, pp.32.

Percy, J. and Redman, S. (1965) Development of a small cassava mill f small processors. *Trop. Agric., Tri* **42** (2), 105-109.

Pereira Calzadillo, O. (1968) La yuca:riqueza potencial inexplotada *Campiña Ahora.*, **2**, (18) 5-6; *Trop. Abstr.* 1969, **24** (10), s 2298, 6

Rao, H.A.G. (1951) Cultivation of cassava and the prepar tion of its products. *Mysore agric.* **27** (3), 57-73.

R -, C.H. (Samoa) (1936) Home-made machine grater. *Pacif. Is Mthly*, **6** (12), 62-63.

Stanton, W.R. and Wallbridge, A. (1969) Fermented food processes. *Process Biochem.*, **4** (4), 45-51.

Sturtevant, W.C. (1969) History and ethnography of some West Indian starches. *The domestication and exploitation of plants and animal* 177-199. Ed. by P.J. Ucko and G.W. Dimbleby. London, G. Duckworth & Co.

Subrahmanyan, V. (1957) Food grains from tapioca. *Fd Sci.*, **6** (8), 183-185.

Subrahmanyan, V., Rao, M.N., Swaminathan, M. (1959) Sago. *Sci. Cult.*, **25** (6), 343-348.

Subrahmanyan, V., Sreenivasan, A., Bhatia, D.S., Bains. G.S. Swaminathan M. (1962) Processing of food tubers with special reference to cassava (tapioca) into enriched macaroni type products. *Proc. 1st Int. Congress, Fd Sci. Technol.*, **4**, 653-678.

Swaminathan, M. Krishna, B.H. Rao, G.R. (1952) A plan for a tapioca soji factory. *Bull. cent. Food technol. Res. Inst., Mysore*, **2**, 79-81.

Vitti, P. (1966) Industrializacao da mandioca, producao de amido, raspa et farinha de raspa. *Bolm Centr. Trop. Pesq. tecnol. Aliment.*, No. 6, 26-33.

Zwankhuizen, M.T. (1962) *Report to the Government of Nigeria on the improvement in processing and utilisation of copra, cassava (gari), rice and cashew nuts suitable for adoption in rural industries. F.A.O. Expanded Tech. Assist. Progr. Rep.*, No. 1529, pp.63.

Industrial uses

Anon.	(1923)	Cassava as a source of power alcohol. *U.K.Dep. Sci. ind. Res., Fuel Res. Bd* pp.13, Appendix pp.9.
Anon.	(1931)	La fabrication de l'alcool par les procèdes H. Boulard. *Prod. colon. (Ca colon. Supp. tech.), Marseille,* 28th (91), 177-184.
Anon.	(1965)	The use of tapioca starch by cotton mills. Views of Mills Federation. *Indian text. J.,* **76** (902), 77-79.
Beeny, J.M.	(1969)	Mechanization of tapioca. Paper rea at *Malaysian Crop Diversification Conference, Kuala Lumpur,* November. pp.14.
Bonnefoy, J.V.	(1931)	La fabrication de l'alcool a base de manioc. *Prod. colon. (Cah. colon. Supp. tech.). Marseille,* 28th Sept. (88), 132-139.
Bravo, A.F.	(1950)	The cultivation of cassava. Plan of an installation to manufacture cassava starch. *Misc. Publ. 330, Min. Agric. Argentina.*
Brautlecht, C.A.	(1953)	*Starch. Its sources, production and uses,* 209-226. New York, Reinhold Publishing Corpn.
Flaws, L.J. and Palmer, E.R.	(1968)	The production of particle board from cassava stalks. *Trop. Prod. Inst. Re G.34,* pp.3.
Füllgrabe, A.	(1956)	Extraction of manioc roots. *Die Stär* **8** (2), 27-37.
Ghosh, B.N.	(1968)	The manufacture of starch from cassava roots in Uganda. *E. Afr. agric. For. J.,* **34** (1), 78-83.
Gutheil, N.C.	(1952)	A industria do alcool de manioca e sua possibilidades no Rio Grande do Sul. *Revta Quim ind., Rio de J.,* **21** (245), 19-22.
Hall, D.M., Sayre, J.G.	(1969)	A scanning electron-microscope study of starches. Part I: Root and tuber starches. *Text. res. J.,* **39** (11), 1044-1052.

Hao, P.L.C. (1957) Production of butanol and acetone from sweet potato, cassava and blackstrap molasses. *Proc. 9th Pacif. Sci. Congress, Pacif. Sci. Assoc., Thailand.* **5**, *Chemistry in the development of natural resources*, 15-19.

Honsch, W.M. (1966) Production and properties of yuca starch (Venezuela). *Die Stärke*, **18** (1), 20-22.

Krishnamurti, B.G. (1960) Tapioca as a source of alcohol. *Curr. Sci.*, **29** (9), 346-348.

Krochmal, A. (1967) Cassava in the New World. *Wld Crops*, **19** (1), 74-75.

Paula, R.D. de G. (1964) Algumas indicacoes sobre industrial de mandioca subprodutos. *Revta Quim ind., Rio de J.*, **33** (386), 20.

Samson, G. (1951) Liquid glucose from cassava starch. *Acta med. Philipp.*, (8), 43-48.

Sandoval, G.M. and Acena, B. (1953-54) A cassava processing plant. *Philipp. agric. Engng J.*, 4th Qtr., 181-183.

Schmidt, H.D. (1965) Erfahrungen in der Thailandischen tapiocastarke und tapioca-mehlindustrie. *Die Stärke*, **17** (11), 351-354.

Serra, P.G. (1955) Modern technique of cassava starch manufacture. *Rev. Brasil. Quim*, **39**, 85-90.

Silva, A. de F. (1964) A mandioca. *Gazeta Agric. Moçamb.*, **16** (179), 109-117.

Subrahmaniam, V. (1952) Note on the preparation of glucose from tapioca starch. *Tapioca Enquiry Committee, Govt. Travancore-Cochin, India. Final Rep.* Appendix H, 97-99.

Suzuki, S. (1964) An overall look at the dextrose industry in Japan. *Die Stärke*, **16**, 285-293.

Teixeira, C., Andreasen, A., Kolachov, P. (1950) Ethyl alcohol from cassava. *Ind. Engng Chem. ind. (int.) Edn.*, **42**, 1781-1783.

Torres, F.	(1953-54)	The manufacture of cassava starch. *Philipp. agric. Engng J.*, 4th Qtr., 184-186.
Tobangui, M.A., Masilungan, V.A. and Hipolito, D.	(1939)	The fermentation of cassava and molass for the production of acetone and norm butyl alcohol. *Philipp. J. Sci.*, **70** (123-131.
Vitti, P.	(1966)	Industrialização da mandioca, producão de amido, raspa e farinha de raspa. *Bolm Cent. trop. Pesq. tecnol. Aliment* (6), 26-33.
Williams, A.E.	(1933)	Glucose from the manioc plant. *Chem. Tr. J.*, **93** (2414), 133-134.

Acena, B. and Salon, D.T. (1959) An economic study of the cassava industry. *Pl. Ind. Dig.*, **22** (9-10), 6-7, 14.

Affran, D.K. (1968) Cassava and its economic importance. *Ghana Fmr*, **12** (4), 172-178.

Albaquerque, M. de (1957) Some aspects of the social economical influence of cassava in Amazonia. *Norte Agron.*, **3** (3), 13-21 and *Chem. Abstr.*, 1958, **52** (2), 1504.

Alberto, J. (1958) A Mandioca. Pt. IV Importancia economica da cultura. *Gazeta agric. Angola*, **3** (6), 266-272.

Anon. (1968) The Federal Republic of Germany, the Netherlands and Belgium. The markets for manioc as a raw material for compound animal feedingstuffs. *Int. Trade Centre, UNCTAD-GATT*, Geneva pp.94.

Arnould, J. -P. (1969) Note sur le marché du manioc dans la CEE. Débouché potential pour les États Africans et Malgaches Associés. *Agron. trop. Paris*, **24**, Ser. 1, 959-969.

Bates, W.N. (1963) *Mechanisation of tropical crops.* 2nd rev. impression, 268-273. London, Temple Press Books Ltd.

Beeny, J.M. (1969) Mechanization of tapioca. Paper read at *Malaysian Crop Diversification Conference, Kuala Lumpur.* November. pp.14.

Brown, L.H. (1963) *A national cash crops policy for Kenya* (Parts I and II), 120-122. *Min. agric. Anim. Husbandry, Kenya.*

Catambay, A.B. (1932) Cost of harvesting cassava with a plow. *Philipp. Agric.*, **21** (4), 277-280.

Catambay, A.B. and Yango, C.E. (1935) Cost of harvesting cassava with animal drawn plow. *Philipp. Agric.*, **23** (8) 662-665.

Checchi and Co. (1964) Prospects for a tapioca starch industry in Guinea. *U.S. Agency for International Development, Rep.* 2067, pp.57.

Faurie, M. (1949) Étude des divers problèmes concernant le manioc a Madagascar. *Congrès du manioc et des plantes féculentes tropicales des territoires de l'Union Française, Inst. colon. Marseille,* 111-117.

Hiranandani, G.J. and Advani, K.H. (1955) *Report on the marketing of tapioca in India. Directorate of Marketing and Inspection, Min. Fd Agric., India, Marketing Series* No. 88. 72.pp.

Jones, E.A. (1968) The prospects for the manufacture of tapioca starch and dried tapioca root in Fiji. *Special Studies, Pap.* No. *Central Planning Office,* Fiji.

Krochmal, A. (1966) Labour input and mechanisation of cassava. *Wld Crops,* **18** (3), 28-30.

Kumar, H. (1962) Mechanisation of cassava planting. *Ghana Fmr.* **6** (3), 102-105.

Lambourne, J. (1937) Experiments on the economic maintenance of soil fertility under continuous cropping with tapioca. *Malay agric.* **25** (4), 134-145.

Leslie, K.A. (1967) The significance of root crops in the tropics. *Proceedings of the International Symposium on Tropical R Crops, Trinidad,* **2**, Section V, 1-17.

Little, Inc., A.D. (1964) *Feasibility of a cassava starch indus in Nigeria. Rep. to the Min. Comm. Fedl Repub. Nigeria,* pp.128.

Little, Inc., A.D. (1964) *International market potential for Nigerian cassava products. Rep. to Min. Comm. Ind., Fedl Repub. Nigeria,* pp.61.

Lulofs, R.B. (1969) A study of method and costs for comme planting of tapioca in Kedah. Paper at *Malaysian Crop Diversification Conference, Kuala Lumpur.* November.

Nijholt, J.A. (1964) *Report on the survey of cassava prod and processing in Ceylon, F.A.O.,* pp

Pushparajah, E. and Yeok, T.S. (1969) Tapioca as an intercrop in rubber. Paper read at *Malaysian Crop Diversification Conference, Kuala Lu* November. pp.10.

Rees, A.M.M. (1962) The cassava industry in Jamaica. *Caribb. Agric.*, I (1), 34-41.

Rees, A.M.M. (1967) Some economic aspects of root crop production with particular reference to the economics of producing carbohydrates from roots as compared with other sources in primitive developing and advanced economies. *Proceedings of the International Symposium on Tropical Root Crops, Trinidad*, **2**, Section V, 18-33.

Sills, V.E. (1959) Cassava starch. Prospects of a cassava starch industry in Fiji. *Fiji agric. J.*, **29** (1), 16-18.

Upton, M. (1966) Agriculture in Uboma. *Uboma - A socio-economic and nutritional survey of a rural community in eastern Nigeria. Int. Geogr. Union, The World Land Use Survey, Occasional Pap.* No. 6, 90-104.

Walker, H. (1966) The market for cassava. *Trop. Prod. Inst. Rep. G.21.* pp.21.

Tropical Products Institute

G52

The preparation of coir or coconut fibre by traditional methods

Tropical Products Institute

G52

The preparation of coir or coconut fibre by traditional methods

August 1970

Tropical Products Institute 56/62 Gray's Inn Road London WCIX 8LT
Ministry of Overseas Development

This report was produced by the Tropical Products Institute, a British Government organisation which helps developing countries to derive greater benefit from their renewable resources.

It specialises in post-harvest problems and will be pleased to answer requests for information and advice. Reports such as this one are often written as the result of an enquiry.

Requests for further information should be addressed to:

The Director,
Tropical Products Institute,
56/62, Gray's Inn Road,
London, WC1X 8LT

THE PREPARATION OF COIR OR COCONUT FIBRE BY TRADITIONAL METHODS

Summary

The extraction of coir by traditional methods✓ for mattress and bristle fibre as carried out in Ceylon is described and also the production of coir yarn in India.

Introduction

Coir fibre is obtained from the fruit of the coconut palm, *(Cocos nucifera L.)*. The fibrous tissue lies between the tough exocarp or outer covering and the hard shell or endocarp which surrounds the kernel.

There are three main types of coir fibre, the longest and finest is known as mat fibre and this is spun into yarn for making mats and ropes, a coarser fibre known as bristle fibre which is used for brushmaking, and a shorter staple fibre known as mattress fibre which is used for stuffing mattresses, upholstery, etc. For upholstery and rubberised coir mattresses it is advantageous to use curled fibre*. This is made by tightly twisting the moist fibre into a "rope". Curled fibre is exported in "ropes" which are untwisted by the user.

The chief supplier of bristle and mattress fibre is Ceylon. In India only mat fibre is prepared and this is spun into yarn or made into mats locally for export. There is a small industry in Ceylon for the production of yarn, and this industry is quite separate from the mattress and bristle production.

Production of Mattress and Bristle Fibre

COLLECTION OF THE FRUITS

For the production of the best grades of fibre the fruits should be gathered before they are quite ripe. If they have ripened the fibre becomes coarser and requires a longer retting period and is also usually darker in colour.

In Ceylon pluckings of the fruit are carried out every alternate month throughout the year, and the best crop is gathered in the May to June period. Men climb the trees to tap the nuts to ensure that they are ready for collecting. They may be broken off or cut off in bunches and dropped to the ground, or from ground level they can be gathered by using short knives attached to long bamboo poles.

✓ See T.P.I. Report G29 for modern methods.

* A note on Rubberised Coir is available.

REMOVAL OF HUSKS

Husks are removed either at the coconut estates or at the fibre mills. Usually the millers buy the husks direct from the estates but if they are also interested in production of copra or desiccated coconut they purchase the complete fruit and remove the husks at their own premises. The husks are broken by striking them against a sharp stake or spike embedded firmly into the ground at a slight angle to the vertical. Alternatively a simple machine such as the Downs dehusking machine can be used.

RETTING

The next stage is the softening of the husks, to facilitate the extraction of the fibre. In Ceylon, retting is carried out in almost any area where stagnant water is available, eg ponds, at a river's edge, or in brackish water, but most commonly in specially dug pits. The average mill has two pits, each about 23m square and each taking up to 100,000 to 200,000 husks. Some of the more modern mills have their own well-built concrete retting tanks, but these are expensive and are therefore comparatively rare. The tanks are generally built in series, each unit measuring roughly 8.0m x 2.7m and being 1.8m in depth. They are built so that the water can be changed frequently and a cleaner, better quality fibre obtained. Sometimes larger concrete tanks about 23m square are used. The water may be changed by pumping it from one tank to another or by adding it from a reserve supply. In some factories retting time is reduced by soaking the husks for 30-40 hours in hot water, they are weighted down with boards and stirred frequently. Periodically the foul water is run off and replaced by clean water at the same temperature. Before soaking, the husks are crushed between fluted rollers to facilitate the penetration of water through the exocarp. At the large mills the total capacity of the tanks is said to be 200,000 crushed husks or 140,000 normal husks.

If the husks have been previously crushed, retting in tanks is complete in 3 to 7 days, otherwise they require 7 to 10 days. In pit retting where the husks are not crushed and the water is not changed the time taken is much longer, from 3 to 6 weeks, according to the position of the husks in the pit, those which are completely submerged require a shorter time than those on the surface. The retted husks are then removed from the pits or tanks by boys who wade into the water waist-high and throw out those husks considered ready for the drums. This can be made easier in the large pits or tanks by marking lanes or passageways with bamboo poles and clearing the lanes one at a time. The top husks which require further retting are thrown into the part of the pit just previously cleared.

EXTRACTION

After retting, the next stage is the extraction of the fibre from the husks. The extraction of fibre requires the breakdown and removal of both the connective tissue, or pith, between the fibres and also the outer exocarp. The process is sometimes called milling or decortication and is carried out using specially constructed machines called "drums". They are usually arranged in pairs one is called the "breaker" drum and the other the "cleaner" drum. The husk segments are first treated at the breaker drum. The drum consists of a wooden wheel about 0.9m in diameter having treads 0.3m wide and 15 cm long, into which have been bolted iron nails 3.8-5 cm apart. The main part of the wheel is enclosed in a wooden guard or casing, having an opening about 30 cm wide protected by a pair of iron bars. The nails are replaced every two months owing to wear and tear, since worn nails tend to split and damage the bristle fibre. The lower part of the casing of the wheel takes the form of a chute whereby the extracted fibre is delivered to the ground below and well clear of the wheels.

As the wheel revolves, first one end of the husk then the other is pressed between the bars. The nails tear away the short mattress fibre which passes down the chute, leaving the longer bristle fibre and pith in the hands of the operator. This bristle fibre is then laid aside for another operator to prepare further on the second or

Cleaning Drum which contains thinner nails placed 2.5 cm to 3.8 cm apart. Bristle fibre from three or four husks is subjected to the same procedure as before, pressing one end then the other against the rotating drum which has finer nails. In this way any remaining short fibre is combed out leaving only the long bristle fibre, which must be at least 8 inches (20 cm) long for the brush trade, in the operator's hands.

It is generally accepted that one pair of drums can handle 2,000 husks in a working day of 8 hours, producing 2 cwt (102 kg)* of bristle and 4 cwt mattress fibre. A small mill, therefore, with three or four pairs of drums should be able to produce 6 to 8 cwt bristle and 12 to 16 cwt mattress fibre per day.

Mattress Fibre

The two grades of fibre are treated separately. Mattress fibre is still wet. It has adhering to it much of the hard exocarp and pith which is separated by passing the material through a rotating horizontal wire mesh drum. Useless short fibre and dust fall through the mesh. The short fibres and pith are put through the sifter a second time, after which the waste is removed to a dust heap or hill. The cleaned mattress fibre is then dried by spreading it on the ground to a depth of about 45 cm. In good sunny weather drying will take about 8 days. During the course of drying, the fibre is turned over a few times to ensure thorough drying. Small boys usually do this by flicking the fibre with a forked stick. When completely dried, it is compressed in hand operated presses into small bales measuring 60 x 36 x 18 cm of approximately 10 lb (4.5 kg) called "ballots", and bound with coir twine.

The mattress fibre is classified at the Shippers' Store, where a few ballots are drawn for sampling purposes. Grading is done according to the fibre colour, length, resilience, and cleanliness generally, particular note being taken of the quantity of pith present. The best type of mattress fibre, "No 1" in the trade, has a golden colour. The next, "Fair Ordinary Brown" has duller colour and less life, while the lowest grade "No 2" is dark in colour. If necessary, after grading, the mattress fibre may be further cleaned by the shippers. In some instances it is teased before being packed for baling. The 153 kg bale varies in capacity from 0.28 cu.m to 0.34 cu.m.

Bristle Fibre

WASHING AND HACKLING

The bristle fibre is taken to special sheds where it is washed in clean fresh water by women and is carefully laid out to dry; when dried the women comb or "hackle" it by drawing it through steel combs or spikes 10-15 cm high, 2.5 cm apart, fixed vertically on a table. "Hackling" removes a further quantity of short-stapled fibre and bits of vegetable matter still adhering, thus giving a better quality of bristle fibre. This fibre is labelled "rough hackled" bristle fibre. At some mills, the bristle fibre is not hackled but after drying is made up into hanks when it is sold as "unhackled one tie" bristle fibre.

GRADING

At the Shippers' Stores, bristle fibre is inspected for its length, colour and stiffness. The commonest quality grades "1 tie" from the fact that the fibre is bound with a single cord of twisted fibre, receives no further treatment except for bleaching. The better quality is further dried and hackled by women, the second hackling being done

* 1 cwt = approximately 51 kg

more thoroughly and carefully. The hanks with the longest staple, about 12 inches (30 cm) long, of good colour, is known as "3 Tie" bristle, the best quality. The next grade of shorter fibre is bound with 2 cords and known as "2 Tie".

BLEACHING

Before shipping the coir fibre is usually bleached to give it a good even colour. Bleaching may be carried out in a specially sealed room having slatted floors under which there are tunnels. Pans of burning sulphur are placed in the tunnels and the fumes of sulphur dioxide bleach the fibre. After 24 hours the bristle fibre should have a uniform golden colour.

DYEING

There are two other processes which are sometimes done at the Shippers' Stores. These are dyeing and drafting. Fibre which it is intended to dye need not undergo bleaching. The fibre in a cage is first lowered into the bath of dye and afterwards allowed to drain. The coir is then carefully dried in special ovens.

DRAFTING

Drafting is really an extra hackling and grading according to fibre lengths. It is a process which calls for skill and experience. The resulting hanks of fibre are cut to a given length and the product is ready for immediate use for the brush trade. Although this treatment is expensive, it is said to be cheaper eventually for the manufacturers who normally have to carry out the process on their own premises.

BALING OF COIR FIBRE

Packing for shipment is usually in the form of 3 cwt (153 kg) bales. The hanks are piled in a steel box about 12 ft (3.7m) high and are hydraulically pressed to a height of about 2.5 ft (75 cm). The bales are then hooped and sewn up in jute hessian. If the fibre is required in "ballot" form ie a rectangular shaped package weighing about 10 lb (45 kg) and bound with coir string or hessian, then hanks are pressed into ballots in a hand-operated press.

Production of Mat or Yarn Fibre

There is a small export of coir yarn from Ceylon but the chief source is India, from where it is exported as yarn or in the form of manufactured coir goods eg mats, matting, carpets and ropes. In India only the one type of fibre is produced ie mat fibre which has a long fine staple, and the preparation is carried out on cottage industry lines while the weaving is done largely in factories.

The better quality of fibre produced in India is attributed to the following factors:-

1. The smaller coconuts give a finer fibre.

2. Plucking the fruits before they are ripe - much earlier than when producing bristle or mattress fibre.

3. The short interval between the plucking, husking, and removal to the retting areas.

4. The very much longer period for retting, which takes from 8-10 months.

5. The frequent removal during retting of foul stagnant water which is replaced at the change of tide by fresh sea water.

6. The clayey nature of the soil where the lagoons are situated.

PLUCKING

In Travancore, the 10 month-old fruits are collected every 45 days. The splitting of the husks is carried out immediately after plucking, and this is done in the same way as in Ceylon.

RETTING

The husks are usually retted for 8-10 months in the back-waters which are quiet and undisturbed and which have an ebb and flow so that there is a constant change of water. These back-waters may be connected with the sea by means of openings or lagoons, and the water then has certain saline properties to which a better quality and brighter colour of the fibre is attributed.

The husks may also be soaked in stagnant water such as in ponds or brooklets, in which case the time required for retting is much shorter than in back-water sections. The resulting fibre, however, is inferior and dull-looking. When the husks are sufficiently soft, they are removed, washed and squeezed in water in order to get rid of the mud and bad smell.

BEATING AND PICKING

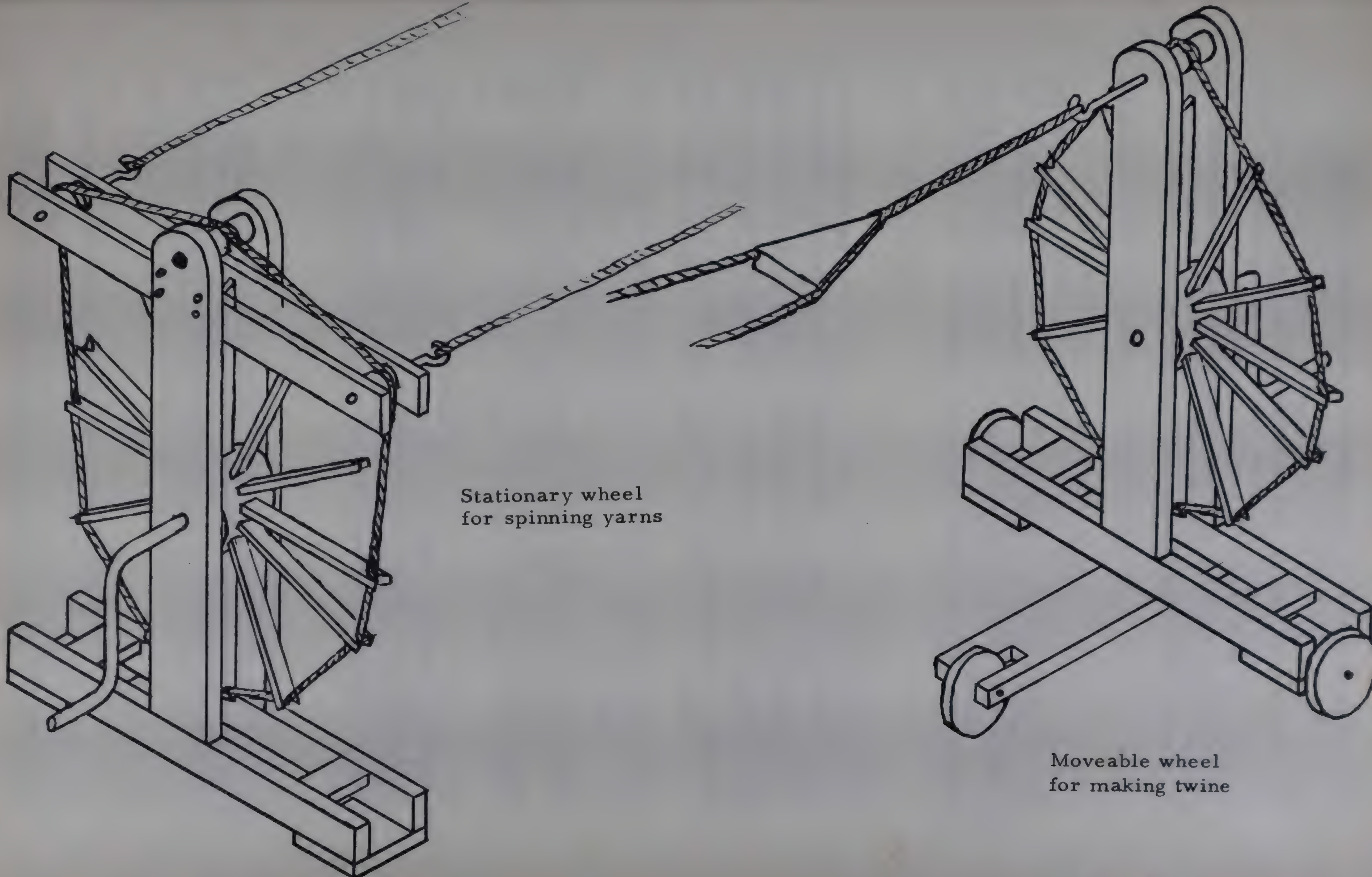
The washed husk segments are then taken to beating places in the banks of the lagoons where there is shade. The fibre next to the inner hard shell is short and this together with the tough exocarp is first removed. The remaining fibrous inside is the part kept for beating out the longer yarn or mat fibre. These pieces of fibrous tissue are placed one by one on a piece of wood and beaten by means of a strong round wooden rod until all the pith is removed. After it is well beaten and softened it is shaken and the fibre washed and spread out by hand to remove any clogged pithy matter still adhering.

DRYING AND WINNOWING

After the fibres have been spread out and dried well they are beaten with a long stick and taken to the winnowing machine to remove small particles of pith. This machine consists of a number of knives with saw-like teeth fixed to a shaft which is rotated by hand in a drum. The fibres are fed in from one side of the machine and pith and other particles fall on the ground and the fibres are thrown in front of the machine, on the other side.

SPINNING

The fibres are now ready for spinning into yarn and this may be done by hand or by wheel. Spinning on the wheel gives a better quality yarn, and is usually carried out by 2 experienced persons assisted by a boy or a girl. Two wheels are required for spinning; one of them is stationary and carries 2 spindles driven by the centre wheel. Fig (a). The other wheel is mounted on 3 castors and has one spindle (b). The spinners each carry a bundle of fibre, sometimes in small mat bags kept under their arms, and they fix the fibre strand to the spindle of the fixed wheel. The fibre is delivered to the thickness of the yarn required and the spinners walk back to the other frame or till the yarn is the required length. At the same time the young assistant turns the



Stationary wheel
for spinning yarns

Moveable wheel
for making twine

Fig. (a)

Fig. (b)

stationary wheel to give the yarn the necessary twist. When the strands have reached the desired length (about 18m) the ends are put together and fixed in the single spindle on the movable wheel.

A triangular block of wood grooved on the sides is introduced between the strands, and this helps to regulate the counter twist, prevents entanglements and binds the strands closely as the spindle on the moveable wheel is turned. The yarn thus twisted is made up into hanks, usually from 15m to 18m in length. Three persons working a set of wheels produce on average from 5 kg to 15 kg of yarn per day.

GRADING

The yarn is classified and graded according to the districts in which it is produced. The two main classes are Hard Twist or Machine Twist yarn and Soft Twist or Hand Twist yarn; the grade name comes from the locality where the yarn was produced.

Hard Twist Yarn. The main grades are Anjengo, Ashtamudy, Alapat, and Aratory and these are each sub-divided into numerous grades.

The Hard Twist yarn is used mainly for the manufacture of matting in factories but certain special kinds are used for rope making.

Soft Twist Yarn. These are classified as "Beach" and "Vycome" and both are again sub-divided into different numbers varying in price. Beach yarn is used for making mats and the finer variety in this class for the manufacture of matting. Similarly, "Vycome" yarn is used mainly for matting manufacture.

Tropical Products Institute

G53

The manufacture of orange squash in developing countries

ERRATA

G 53 The manufacture of orange squash in developing countries

p. 29. The 2nd and 3rd lines of the formula should read:

$$\frac{R^2}{2} = r$$

$$\sqrt{\tfrac{1}{2}R} = r = 13.25 \text{ miles}$$

p. 30. Columns j. and k. Line 9 of this heading should read:

'13,640 lb. - (5,140 lb.+ 1,120 lb.) = 7,380 lb. = 3.3 tons'

p. 52. (Table 9) Column f. (Cost per shift) should read:

'Col. $\frac{c \times e}{20}$'

p. 63. (Table 20). Footnote at bottom left should read:

'See text pages 31-32'.

Tropical Products Institute Report

G53

The manufacture of orange squash in developing countries

Penelope A. Mars

March 1971 Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU

The Manufacture of Orange Squash in Developing Countries

Contents

List of Tables

The Manufacture of Orange Squash in Developing Countries

Part I

The Cost Structure

1 The Scope and Purpose of the Report

General

This report is one of a series, designed with the purpose both of serving local entrepreneurs and economic planning organisations in developing countries as a basis for making decisions or, if external help is necessary, as a blueprint for feasibility surveys to be carried out by economists from the Tropical Products Institute.

The main emphasis in the report is on a series of real (physical) cost models giving the inputs of factory floorspace, labour, machinery services and materials required for a range of small to medium outputs, depending on certain labour intensive combinations of labour and capital, which are assumed to produce at typical levels of efficiency. Given this information, anyone who has assessed the market for a certain product, which was previously imported into a developing country, can then proceed to find out what it would cost to produce that output at local factor costs. The next step in making an investment decision is to ask whether, given the market, the enterprise would be profitable either immediately or in the near future.

Alternatively, in the case of products which are not imported or already manufactured and are unknown in the area, the models would facilitate the estimation of a local price for the purpose of test-marketing the product.

Although prominence is given in the reports to costs in real or physical terms, which can be used as a basis for computing money costs in any country and at any time (provided that the technique does not become obsolete), a full costing has also been carried out in terms of the factor costs prevailing in a West African country in mid-1967*. This gives the reader a rough idea of the cost and possible profit per unit at different levels of output, which may make possible a preliminary decision as to the most appropriate scale for the existing market. In addition, this part of the report explores the concept of economies of scale.

The report includes a description of the methods of processing, sufficiently detailed to make the physical costing information comprehensible, and flexible, and also to indicate the main technical and operational difficulties, since the entrepreneur must assess his capacity to resolve them in local conditions. The report is not intended to serve as a production handbook, but as an aid to economic decision making. Normally the successful launching of a new undertaking requires expert technical supervision on the spot, which may have to be maintained over a long period.

Products of the orange

The physical composition of the orange, which is an aid to understanding the various products associated with orange juice and is also relevant to later sections of the report, is given below:[1]

---

* A method of bringing the prices of imported items, such as machinery, up to date is given on pages 36-37.

Component	Per centage by weight
Juice	
Juice	40 - 45
Flavedo (outer peel)	8 - 10
Albedo (inner peel)	15 - 30
Rag and pulp	20 - 30
Seeds	0 - 4

Juice products. Single strength juice, from which orange squash may be made, is now produced largely for direct consumption and is packed after preservation in cans or bottles. Juice intended for further processing is generally concentrated, the two main processes used being by vacuum or freezing. As far as the soft drinks industry is concerned concentrates, may be used directly as a raw material, or they may be converted into 'compounds' which contain extra colour and flavouring materials. Compounds are purchased by the soft drinks trade for simple manufacture of soft drinks. (Very little freeze-dried concentrate is used for squashes.)

Peel products. The main products based on orange peel are animal feeds, pectins and essential oils. Peel may also be used to make pectin, candied at the factory or preserved in brine and exported as material for candied peel or marmalade, although normally marmalade requires orange pulp as well as peel. These products are of minor importance.

Peel is being used to an increasing extent in "comminuted" (or finely ground) form in "whole orange drinks", for dilution on direct consumption and in "comminuted bases" which are sold as intermediate materials for the whole orange drinks. These drinks also contain juice and possibly a proportion of other solid parts of the orange.[2]

The relative importance of some of these products is discussed in a later section.

The Choice of Orange Squash

Squashes have been defined as consisting, "in the main, of varied mixtures of citrus juices with fine cane sugar or cane sugar syrups, and with additional flavouring ingredients such as citric acid, essential oils or essences, colouring matter, etc."[3] Beet sugar may be used, and preservatives are usually added.

The manufacture of orange squash was considered to be a suitable subject for a report of this nature for several reasons. In the first place, the geographical distribution of oranges is wide and output appears to have increased at a high rate.

Annual average production of oranges and tangerines in developed countries is estimated to have increased from 8.9 million tons in 1953-55 to 10.1 million tons in 1962-64, an increase of 13 per cent. The corresponding figures for developing countries are 5.1 million tons in 1953-55 and 7.7 million tons in 1962-64, an increase of 50 per cent. There is said to be over-production of fresh citrus fruit, while the demand for prepared foods is increasing, owing to changing standards and ways of living.[4] Orange growers in developing countries are thus seeking outlets for their product other than the fresh fruit market.

Industries which can be viable on a small scale are suitable for developing countries owing to the prevailing shortage of capital and entrepreneurial skill.

In a study of small scale industries suitable for developing countries, the authors place bottled and canned soft drinks in the category of products with local markets and high transfer costs, on which they comment as follows:

> "Product transfer costs .... tend to exceed transfer costs of the material inputs, favoring plant location near the consuming markets. Transfer costs of the finished products are high in relation to potential scale economies as well. The production process accounts for a moderate to substantial share of total costs but involves relatively simple mixing, assembly, or physical operations offering only low or moderate advantage to large-scale production. Incentive to gain this moderate advantage by serving several markets from a central plant is inhibited, in greater or less degree, by the cost of product transfer."(5)

The findings of this report do not substantiate the assertion that transfer costs of the finished product are high in relation to economies of scale, in so far as domestic production and local transport costs are concerned. However, it is very true with regard to transport costs on imported squash, and the production of orange squash seems to be eligible for inclusion in programmes for import substitution.

Many other tropical fruits can be used for making squash (see page 5). However, orange squash is said to be the most popular.

It is probable that it is the marketing attributes of orange squash production which most favour its establishment in developing countries. The climate in hot countries stimulates consumption of beverages and squash has the advantage that it can be retailed in very small quantities, i.e., by the glass which can be cheap enough to sell to people with very low incomes. When sold for household consumption it has the advantages that it is inevitably packaged in a container suitable for storage even in households which do not contain such rudimentary storage equipment as shelves, and will keep for a reasonable time without refrigeration.

Other Relevant Aspects of Orange Processing Industries

The manufacture of orange squash from locally grown oranges actually plays a minor role in the complex of orange processing industries, whose products have been listed on page 2.

The importance of various forms of citrus juice in international trade is illustrated by the fact that in 1964 citrus juice imports into the United Kingdom reached a level of some 200,000 tons of fresh fruit, compared with actual fresh citrus fruit imports of 500,000 tons(6). It was consequently decided at an early stage that the importance of orange juice as an export product might justify the preparation of a further report, defining the equipment and other requirements for producing concentrated orange juice on a small scale. This report would also deal in less detail with the production of natural strength juice, frozen concentrated juice and concentrated comminuted orange.

A short questionnaire was sent to a number of tropical orange producing countries in order to obtain some direct information about the structure of their orange processing industries and the typical scale of juice production. An important fact which emerged was that in certain orange producing areas, namely Brazil, Bolivia and the East Caribbean, popular orange beverages are made not from juice extracted in the same factory but from ingredients based on oranges which might be manufactured in other countries and imported.

This disclosure led to the decision to investigate in the main report the economics of orange squash industries based on imported orange compound.

The subject of the "comminuted citrus drink", defined in the British Soft Drinks Regulations as "a soft drink produced by a process involving the comminution (pulverisation) of the entire citrus fruit", has not been dealt with fully in this report.(7) These drinks which may, like squash, require dilution or appear in a ready-to-drink form first appeared on the British market in 1953. By 1965, the output in Britain of comminuted drinks for dilution exceeded that of squashes and cordials.

While the advantage of comminuted citrus drinks over squash from the consumer's point of view appears to lie in the "peely" flavour, resulting from the inclusion of peel as well as juice, their economic advantage from the producer's point of view seems to be due to the peel flavour making unnecessary the addition of other fruit flavouring materials,(8) and to the fact that a larger amount of "drink" for dilution can evidently be derived from a given amount of oranges. According to the British Soft Drinks Regulations 1964, a comminuted citrus drink for consumption after dilution shall contain 10 lb. potable citrus fruit content per 10 gallons while a citrus squash must contain 25 per cent citrus fruit juice by volume.(9) An additional advantage of comminuted drinks is that no preservative such as sulphur dioxide (SO_2) is necessary.

Some information would be given in the proposed report on orange juice processing, on the manufacture of a comminuted "base" for export or utilisation by independent beverage manufacturers in the citrus growing area. The comminuted base may be used for making a "whole fruit" beverage for dilution by methods similar to those used for making orange squash from compound. Whole fruit beverages may also be made directly from oranges by a small scale comminution process.

Outline of the Report

The remaining chapters of Part I of the report deal with the manufacture of orange squash from oranges or imported "compound" at four different levels of output. The choice of the assumption upon which the models are based is explained first, and then, because comparisons can only be made in monetary terms, the results of the costings at local prices in a West African country are discussed. The method of production is then described.

Part II of the report covers the sources of information and methods of calculation used in the tables, which are dealt with in numerical order. Appendix I gives some additional information which might be required in carrying out feasibility surveys. Appendix II gives a list of persons, firms and institutions who, in addition to colleagues at the Tropical Products Institute, kindly supplied information for the report.

2 The Design of the Models

Tables 4 to 7 give quantities and cost of equipment and stores, as well as quantities of power and floorspace for machinery and labour complements required at four different levels of output. Table 1 summarises the cost structure of the models.

The general aim in deciding on assumptions was to make the models useful and typical. Many of the assumptions were based on information given in a questionnaire (later referred to as "The questionnaire") by a fruit squash factory operating in West Africa. These include the geographical location of

the factory, the technique of production and many of the factor costs. The system of taxation used in the model is that of the country in which the actual factory is situated. Although the calculations have in most cases been made to a larger number of decimal places, the values quoted in the tables have been rounded to three significant figures. This may have given rise to discrepancies in totals.

Scale and Type of Output

A rigorous method of investigating economies of scale involves balancing the lines of equipment to the output of the most expensive item. In the present case, the levels of output on which the models are based were suggested by a director of the firm of machinery makers which supplied information about many items of machinery used in the models; namely 300, 600, 1,200 and 2,400 26.2/3 oz bottles of orange squash. These were regarded as suitable scales of output for small firms in developing countries, and are commercially orientated since the soft drinks trade thinks in terms of hundreds of dozens of bottles. The models of increasing size are referred to as scales A, B, C and D. For each scale, three alternatives have been considered, namely, I, producing squash from oranges during the crop season of four months, and closing down during the remainder of the year, II, producing squash from oranges during four months and from imported compound during eight months, and III, producing squash from imported compound for the whole year.

The orange season lasts four months in the West African country mentioned above, and the factory which provided answers for the questionnaire actually made squashes from grapefruit, lemons, limes and pineapple, thus maintaining production during eight months. Squash may also be made from mangoes, guavas and pineapples by using different juice extraction machinery.

Some small fruit processing factories in the tropics make other products such as jam and chutney and canned fruit in addition to squash. The manufacture of animal feed and molasses from waste citrus peel is normally undertaken by larger factories than those under consideration here.

This report was restricted to orange squash since this is already a complex subject for a report. However, the information in the report as it stands may be regarded as a nucleus to which additional components may be added, and when the establishment of an actual orange squash plant is being considered, the raw material supplies and marketing prospects for expanding the range of products should be investigated. Alternatively, a local market survey, might reveal that the product would sell better in a smaller bottle containing say 10 fluid oz. or in locally available beer bottles. In this case fresh estimates of bottle requirements and costs and some fairly obvious adjustments to the operating system would have to be made.

Information on processing other products or advice on modifying the mode of operation can be supplied by the Tropical Products Institute.

Mode of Operations

The models are assumed to operate on a single shift of eight hours a day for a 40 hour week. The working year consists of 240 days or 12 months of 20 days each. This simplification reflects sufficiently accurately, working conditions in developing countries where public holidays are frequent. Within the day, the running time is assumed to be 80 per cent of the total time, so that the machinery is working for at most 6.4 hours per day. The remaining 1.6 hours is allocated to cleaning.

Techniques

In order to minimise both capital costs and the scale of production labour intensive techniques were chosen in preference to capital intensive ones. For example, the smallest automatic juice extractor which halves the fruit, extracts and sieves the juice would have cost in October 1967 about £2,650 delivered at factory, and has a maximum capacity of 2.3 tons of oranges per hour. A manually operated juice extractor costs £260 delivered and has a capacity of 600 lb. of oranges. Together with equipment for halving and sieving, the total cost was £777 (Table 4, i, 3, 4, 5). The second technique is still used successfully in developing countries where labour is relatively cheap, and makes small scale production commercially possible. The models have therefore been based on this method of juice extraction.* Similar arguments apply to the use of steam jacketed pans for pasteurising juice as opposed to the more capital-intensive pasteurisation process.

Given the method of production, the necessary equipment is listed in column a. of Tables 4 to 7. The number of items of each type of equipment (column h) depends on its capacity (column b), and on the weight or volume of material to be processed, which is stated at the top left hand side of each of Tables 4 to 7. The amount of material to be processed depends on the characteristics of the oranges (where they are used) and on the squash recipes.

Assumptions about oranges

Oranges vary considerably in weight. For the purposes of this calculation, 10 oranges are assumed to weight 4 lb., which is approximate to the available information on weights of oranges produced in certain tropical countries.(10) As stated above the juice yield varies between 32 per cent and 45 per cent of the weight of the fruit. Here, it is assumed to be 40 per cent. With the method of extraction assumed, the yield depends on sorting the oranges into suitable sizes for the machine.

The specific gravity of orange juice varies between 1.03 and 1.06. All calculations involving specific gravity have been based on a value of 1.045.(11)

A certain proportion of the oranges are normally found to be unfit for processing. The waste factor is assumed to be 4 per cent of the oranges delivered to the factory.

The Recipes

The recipe for squash made from oranges used in the calculation is one recommended for use in India.(12). The quantities of oranges and other ingredients required are shown in column c. of Table 9. The recipe conforms with the requirements of the British Soft Drinks Regulations, 1964.(13) The recipe for squash made from compound was supplied by the firm which manufactures compound, except that the quantity of sugar was increased to that

---

* The more capital-intensive machine, which is made in Italy, is evidently a recent model and became known at a later stage in the preparation of this report. It is probable that it would be economic to use it at the output assumed in the largest model, processing 1.34 tons of oranges per hour. An alternative calculation has not been attempted in the report. Details about the machine are included in Appendix I, and could be used in a feasibility survey.

specified in the recipe for squash made from oranges for the sake of comparability. Compound contains no sweetening matter. The quantities of materials required are shown in column c. of Table 10.

Power and Fuel

The power supply is assumed to be 400 volts, 3 phase, 50 cycles and the electric motors included in the quotations in tables 4 to 7 quoted for are suitable for this supply.

In the geographical area where the factories are assumed to lie, wood is plentiful and it is assumed that a common type of wood is used to heat the boilers. Wood is scarce in many developing countries, so that the effect on costs of using oil instead of wood is indicated in Appendix I on page 34.

Transportation

In the course of a feasibility survey, estimates of transport requirements and costs would have to be based on actual data for supplies and channels of distribution. In this report, estimates were attempted using some data on journeys supplied by the West African soft drinks manufacturer and reliable information about transport costs in the same country. The object of this was to make realistic estimates of transport requirements for a soft drinks firm in a developing country, and the order of magnitude of transport costs in relation to other costs. However, on the assumptions stated in pages 28 to 31, the costs of distribution are likely to have been underestimated (see below page 15).

Oranges. The oranges are assumed to be grown by peasants scattered over a fairly wide area. Although in many cases produce-processing factories pay for the raw material delivered at the factory gate, it is assumed in these models that the squash firms are responsible for transporting oranges, because this procedure gives them more control over the supplies. Since production of squash from oranges is seasonal, it would not be economic to own and operate vehicles for the purpose of orange collection only, so that where there is no surplus capacity in lorries owned for the purpose of distributing squash, it is assumed that hired transport is used for collecting oranges. Surplus capacity occurs only in case AI (Table 1, b, 20). Table 15 shows how the distances and necessary numbers of lorries have been estimated.

Distribution. Distribution of full bottles and collection of empties is normally undertaken by the producing firm in the soft drinks industry, and this procedure is assumed here. Again, distances and lorry requirements are calculated in Table 15. Table 16 gives estimates of transport costs, based on the distances calculated in Table 15. The firms are assumed to used their transport only for distribution and collection of bottles, and, in case AI, for collecting oranges. In reality, the lorries would be used for other tasks such as fetching materials. In the present calculation, all prices described as "delivered at factory" include an allowance for cost of transport.

Working Capital

"For a new project it is the cash on hand at or just before the start of commercial operations. It will be invested in stocks of raw materials and supplies, and in labour and other cash production costs. It will stay invested in the product while it is being processed, while it rests in

inventory as finished goods awaiting sale, and even after it is sold - until the customer finally pays cash for it".(13) In the present calculation separate estimates have been made, under the heading "stores", for stocks of main items of supplies testing equipment and spare parts. Labour and raw materials are treated as cash production costs for which provision has to be made initially.

Stores. Estimates of working capital for stores are shown in rows 21 to 29 of Tables 4 to 7. The stock of bottles is assumed to be enough for six weeks' production, i.e. 400 gross at scale A. At any moment there is two weeks' supply in the factory, half of which are full waiting to go out and half of which are waiting to be filled. The remainder are assumed to be out at depots, in retail establishments and private dwellings. The bottles are assumed to last on average for 10 trips, which is equivalent to saying that 10 per cent are lost each time they go out.

A six weeks' supply of cartons is also assumed. The cartons which hold 12 bottles can only be used once.

Testing Equipment. In practice soft drinks manufacturers in developing countries sometimes make use of the Government analyst's services for testing their products. Because quality control is very important and experts consider that each factory should have its own testing facilities, it has been assumed that all the models have a quality control scheme. Row 23 of Tables 4 to 7, shows the estimated cost of equipment and materials for this purpose, together with the labour complement.

Spare Parts. M. D. Bryce(14) recommends an allowance as high as 20 per cent of the total cost of basic machinery and equipment, because "the unavailability of spare parts for machinery is one of the great hazards of building a new industry in a non-industrial area." This allowance is shown in rows 24 to 26 of Tables 4 to 7.

Cash. The firms are assumed to operate on a cash basis, i.e., without giving credit. Consequently, cash resources to cover one month's operating expenses should be adequate. However the estimated working capital shown in row 9 of Table 1 is based on two months cash operating expenses to cover possible under-estimates under the "Stores" heading and to allow the firm a margin for the difficulties of starting up.

Depreciation

Depreciation is charged at 5 per cent on buildings and 10 per cent on machinery, and equipment. Depreciation for lorries is based on three or four years life depending on usage. (See Table 16).

Extra Allowances

Inevitably, the present calculation is bound to be less accurate and detailed than a final specification for an actual project which is expected to go into operation. Consequently Table 1 shows two extra items. In row 8, there is an allowance of 20 per cent on the total fixed capital costs to cover "installation and unforseens", and in row 28, a similar allowance of 10 per cent is made on total cash operating costs.

3 Outline of the Manufacturing Processes

Buildings and Services

No attempt is made here to specify exactly the kind of building required. It is essential that it should be capable of being kept extremely clean. A single storey building of fairly light construction is assumed in this report, although in Britain the syrup mixing room is commonly on an upper floor so that the syrup can flow down into the bottling department. "Flooring should be firm and of good cement to withstand the constant use of water. A slope of about one quarter of an inch per foot is necessary for proper drainage. All doors, windows and ventilators should be provided with fine wire-gauze to prevent entrance of flies, wasps and other insects. The roof of the building should be high and well ventilated to provide outlet for vapours and steam. The windows should have large glass panes, and part of the roof should be of ground glass to permit a gentle light inside."(15)

Steam boilers are required in all cases where orange juice is processed (for pasteurisation) and also in case D III, where steam is used in the bottle washing machine. In all other cases, where squash is made from compound, only hot water boilers are required.

As shown in rows 10 and 14 of Table 22, very large quantities of water are required ranging from 1,200 gallons per shift in case A III to 6,500 gallons per shift in case D I. The water should be of good potable quality, with no bacterial contamination and virtually no colour or odour, and the water used in the final drink should not be too alkaline nor too hard since too much alkalinity would neutralise the acidity of the drink which contributes to its refreshing nature, while the use of hard water in squash may affect its appearance by reducing cloud stability (or opacity due to fine suspended particles).

Drainage facilities and an electricity supply are also necessary. In the absence of the latter, generating plant would be required.

About 60 per cent of the weight of oranges entering the factory is waste material and if this cannot be converted into animal feed, it must be removed from the factory area and dumped. In the latter case the main expenditure for disposal of waste would be the cost of handling and transportation from the factory site. In cases where there is a properly organised dump operated under the control of local authorities, it is unlikely that a charge would be made for dumping. If the factory operates its own dumping ground this might be made freely available as part of a soil improvement scheme.(16)

A firm in West Africa, processing 5 to 6 tons of fruit per day, reported that there are gutters in the factory floor into which all excess pulp, etc, is washed. This effluent goes into an external gutter which conveys it into a covered underground pit. On the way, the liquid passes through two fine wire mesh baskets which trap the solid waste matter. This waste is carted away with the peel in a small road-dumper to a disused gravel pit at a safe distance from the factory. The weight of the dumped waste might amount to about 40 per cent of the weight of oranges processed. The cost of this operation was said to be negligible.

No allowance has been made in the costing for waste disposal, apart from the allowance for unforseens at 10 per cent of cash operating costs in row 28 of Table 1. A careful estimate would have to be made in a feasibility survey.

Hygiene

Since squash is a food product, the highest standard of cleanliness is required for personnel, plant and buildings. When the equipment become contaminated, yeast bacteria or mould micro-organisms begin to appear in the finished beverage. Increased numbers of these organisms will cause .... ultimate spoilage of the product."*

Hence, in these models, 20 per cent of the operating time is allocated to cleaning. Juice extraction may start as soon as the factory opens in the morning; meanwhile, the syruping and bottling equipment is being cleaned thoroughly before starting to operate. No juice or syrup should be left standing over-night, and in order to achieve this, the last batch may, in practice have to be a partial one.

Bottle washing should be synchronised so that a batch of bottles is ready for the first batch of squash.

"For carrying out sanitary operations in the plant, the following, at least, will be needed: A soapless cleaner for the equipment, as well as for maintenance operations: a chlorine sanitizer for the machinery that handles both the water (juice) and the syrup: a caustic base product for washing and sanitizing bottles; a product for polishing and removing stains from metals, tile and enameled surfaces; an abundance of hot and cold water; necessary brushes, sponges, pails and cloths, and a squeegee for removing excess water." (17)

These items have not been allowed for specifically in the costing, but are covered under the heading "Other Costs" in row 28 of Table 1.

Reception and Storage

Ideally, the oranges are carried by lorry to the factory in field boxes. As boxes are expensive, the fruit are usually brought loose in the lorry, from which they are unloaded and after weighing placed in storage bins. Although these may be of a high rectangular design with sloping baffles, which minimise pressure and allow the fruit to roll down to an aperture at the bottom, the bins may be simple tank-like wooden structures, in which the fruit may lie not more than three feet deep.(18) As stored oranges tend to deteriorate even within 48 hours, the storage space, consisting of horizontal bins, is designed for only two day's supply.

Washing

The fruit are carried in baskets from the storage bins, and fed into the hopper of the washing machine. Alternatively, the fruit could be conveyed in flumes, which may be made from halved 45 gallon oil drums and polythene sheeting. More running water would be required. (If essential oil were to be extracted from the skin, the process would be carried out before washing. However, it is assumed that there is no production of essential oil because it is not in demand.)

At scales A and B, the washing machine comprises a rectangular open topped tank mounted on legs, the whole being galvanised after manufacture. The tank is divided across the centre into two compartments end to end. On a

*Chapters of the Book by Ruiz(17) deal with water and water treatment, plant sanitation, quality control and plant layout as well as with processing aspects of soft drink manufacture.

central drive shaft traversing the length of the tank are mounted two cylinders of perforated metal, one lying in each of the compartments. The fruit is fed by hopper into the first cylinder which revolves in heated water. A helical strip attached to the inner surface of the cylinder causes the fruit to move forward until it is picked up by elevator plates attached to the end of the first cylinder, which bring about the transfer of the fruit to a cold water rinse in the second cylinder. The manufacturer did not state the maximum throughput of this machine.

The larger washing machine used at scales C and D is of the tunnel type, the fruit being passed through the washing process, which also involves both hot and cold water, on a suitable conveyor.

A germicidal and detergent preparation may be added to the water, which should be changed continuously.

Sorting

After washing, the fruit is carried by operatives to sorting tables where it is inspected and defective fruit is eliminated. At this stage the fruit is sorted into different sizes, (small, medium and large) to facilitate a high rate of juice extraction, achieved by fitting the fruit to the extraction device.

Halving

The clean oranges are carried to the halving machine. This machine operates like a bacon slicer with a circular stainless steel blade 15 inches in diameter. The fruit are carried to the blade in cups situated on the edge of a rotary aluminium hopper, the cups being deeply grooved to allow access to the oranges by the blade. The operative's task is to drop the oranges into the cups and remove the halved oranges in clean buckets to the juice extraction machines.

Juice Extraction

The juice extraction machine is double-headed. Each "head" consist of a reaming rosette, a ribbed cone made of plastic or monel metal, and resembling a household lemon squeezer, mounted horizontally upon a spindle inside a bowl-shaped hood (monel metal is a corrosion-resisting alloy of nickel and copper). The rosette is rotated by the spindle while the operative holds the halved orange against it until the juice, pips and rag are extracted and fall into the hood, discharging into a bucket placed beneath. The hood and bucket are made of stainless steel. Rosettes are of different sizes.

Juice Separation

In scales A and B pips and rag are removed from the juice by centrifugal action in a cylindrical drum which is lined with an acid resistant lining. The juice pulp and pips are placed in a linen bag inside the drum, which is fixed vertically above a motor drive, when the drum rotates at high speed. The juice is expelled into the drum leaving the pips in the bag. The bags are kept sterile by washing with detergent and soaking in a chlorine solution.

At scales C and D, the extracted juice etc. is placed in a fruit sieving machine, in which the pulped fruit is forced through a sieve by paddles attached to a revolving shaft.

Pasteurising

Pasteurisation, in this context, has been defined as: "The treatment of liquid food products to ensure ..... the destruction of micro-organisms and inactivation of enzymes to enable food to be preserved for a prolonged or indefinite period". Conditions used for pasteurising citrus juices are primarily determined by the necessity for inactivating pectin enzymes, which are present in the original fruit or may be produced by micro-organisms which may enter the juice. It is necessary to remove these enzymes by heat treatment because they destroy the pectins which preserve the cloudy state of freshly extracted citrus juice. A juice from which cloud constituents have deposited as a sediment is less esteemed than a cloudy one.[19]

The juice is carried in buckets and poured into the steam jacketed pan(s). It is raised to a temperature of 190°F. and held there for 1 minute.[20] It is then poured into the blending vessel.

Syruping

The making of the syrup should be timed so that a batch of pasteurised juice and a batch of syrup are ready at approximately the same time to be mixed together in the blending vessel.

The cold process syrup-maker included in the specification includes an agitator and incorporates a cylindrical filtering unit with pump, fitted at the side of the machine.

The vessel is filled with the appropriate quantity of cold water (in accordance with the recipe in Table 9), the agitator is then switched on and the sugar which should be of the refined granulated type is introduced gradually. When all the sugar is in the vessel the pumping unit is switched on to circulate mixture of sugar and water, through the filter and back into the vessel. This system of circulation ensures the dissolving of sugar granules and will provide an even mixture. If a lighter and cheaper syrup is required, saccharine may be substituted for part of the sugar. (According to the British Soft Drinks Regulations, 1964 the maximum quantity of saccharin permitted in orange squash is 280 grains per 10 gallons).[21]

Although it is common practice for the syrup room to be situated on the first floor of the buildings, so that the syrup flows by gravity into the blending vessel, a single storey building is assumed in the present calculation, and the syrup is pumped into the blending vessel.

Blending

In the stainless steel blending vessels, which are also equipped with agitators, the pasteurised juice and syrup are mixed together with the other ingredients as listed in Table 9. These are sugar, citric acid, essence of orange, orange colour and preservative. The latter is potassium metabisulphite which is used as a source of sulphur dioxide. According to the Indian Fruit Products Order, the maximum amount of sulphur dioxide allowed in squashes and cordials, is 350 parts per million. This corresponds to about 2 ounce of potassium metabisulphite per 100 lb. of squash.[22]

The blending of orange squash from compound differs only in that there are fewer ingredients. (see Table 10).

In the smaller units, the squash is led from one of the blending vessels by means of a flexible hose coupling. At scale D an additional pump might be used.*

Filling

At scales A, B and C, filling is effected by simple hand operated syphon machines having either six or eight spouts. In this machine, there is a stainless steel trough which holds the squash ready to be filled. The bottles rest on a stand in front of the machine, and the squash is syphoned into them through steel tubes. The bottles are removed by hand and taken to the capping table.

At scale D an 18-headed vacuum-assisted bottle filling machine is assumed to be used. The surfaces in contact with the squash are made of stainless steel. With this type of machine, the air is drawn out of the bottle by a vacuum, which facilitates filling. The bottles are automatically fed to and discharged from the filling valves.

In all cases the bottling, capping and labelling machines are placed close to each other. Some additional unskilled labour or a conveyor belt may be required to move bottles at this stage.

Capping and Labelling

It is assumed that re-usable crown caps with a polythene insert are applied since they facilitate storage of the squash after the bottle has been opened.

At scales A and B, the caps are put on by a small hand-operated machine and the labels are pasted on by hand. At scale C, semi-automatic capping and labelling machines are used. In the former, the crown is mechanically placed upon the bottle and sealed by a hand-operated lever. The latter machine has a magazine, in which a pack of labels is placed. The operator places slight pressure on the foot treadle of the machine to actuate the complete labelling sequence in which the label is taken from the stack, placed on bottle and wiped round the surface of the bottle.

In scale D, both the crowning and labelling machines are fully automatic.

Bottle Washing

As the scale of operations increases, bottle washing is carried out by machines of increasing complexity. The simplest consists of a rectangular tank with a brushing unit, in which the bottles are washed in hot water and then rinsed. At scale D, a larger machine of the tunnel type is assumed. The bottles are loaded onto a conveyor which carries them into the interior where they are sprayed with hot and cold water and the labels are removed mechanically. As mentioned above, the hot water should include a detergent solution of caustic soda (80 per cent) and Calgon (20 per cent) to sterilize the bottles and facilitate removal of labels.

The bottles are carried to the filling unit either by hand in crates or at scale D by conveyor.

---

*The price of the centrifugal pumps covered in the specifications in Tables 4 to 7 was £64. 10s. 0d. f.o.b. London in mid-1967. No pump has been included with the blending vessels.

Storage

Full bottles are placed in cartons and carried by hand to the store except at scale D where a conveyor is used. The labour for this task is shown in row 22 of Tables 4 to 7.

Quality Control

The maintenance of standards of purity and uniformity in the product is of great importance in the manufacture of orange squash and other soft drinks, and it is essential that the manager of the factory should be capable of supervising quality control tests which may be carried out by semi-skilled staff in a suitably equipped testing room.

It may be considered necessary to test samples of the oranges before acceptance for maturity. This involves determining the ratio between the proportion of total soluble solids (primarily sugar) and the proportion of citric acid in the juice. Values of the ratio within a certain range, make the juice acceptable for processing.

A normal commercial quality control system would involve performing the following tests in the course of production.

Each batch of syrup should be tested for the sugar content, so that this can be adjusted before blending.

Before bottling, each batch of the blended squash should be tested for the following attributes: flavour by taste, appearance by inspection, sugar content and acidity. The last two tasks require apparatus. Finally, the preservative content of the squash has to be checked. Since the commonest faults are the omission of preservative, or the addition of a double dose, a roughly quantitative test for sulphur dioxide should be done on every batch. Direct titration with iodine is considered adequate by the trade and takes less than five minutes. Where, as in Britain, there is a maximum limit for the amount of preservative in squash, a more rigorous test requiring relatively expensive equipment and taking from one-and-a-half to two hours is necessary. In order to avoid holding up the flow of production, this is normally done after the squash has been bottled, and acts as a "police" check.

In order to test the efficiency of pasteurisation, a sample bottle from each batch should be kept for fourteen days to ascertain whether the cloudy appearance of the beverage is maintained.

Finally, there should be periodic checks to ascertain the presence of yeast, moulds and bacteria, and remedial action taken if high levels of contamination are detected. In the first instance, expert assistance must be obtained to carry out the necessary tests, but factories operating at scales C and D should aim to become independent in this respect.

4 The Results of Costing the Models

General Observations

Tables 4 to 20 of the report show the physical quantities of equipment and other imports required for producing squash from fresh oranges or compound.

All quantities apart from fixed capital (which is shown in Tables 4 to 8) are given on the basis of requirements for one shift of 6.4 operating

hours. Quantities of raw materials and supplies are given in Tables 9, 10 and 11 for scale A only; i.e. they relate to the model factory producing at the rate of 300 bottles per running hour. The quantities appropriate to scales B, C and D can be easily derived by simple multiplication.

None of the other factor inputs increase in simple ratio from model to model, so that the required quantities for operating one shift are shown separately for each model. Tables 12 to 14 deal with electric power, wood fuel and water. Transport for orange collection and squash distribution are dealt with in Tables 15 and 16. Personnel is covered in Tables 17 to 20.

The situation of the factories is assumed to be well endowed with wood suitable for fuel. In many developing countries wood fuel is not available. In such cases oil might be used as an alternative, which would entail certain changes in capital and operating costs. Some information relating to these changes is given in Appendix I.

Values of all items are shown in the tables at prices in sterling in mid-1957 delivered at a West African factory, and in nearly all cases where the item is imported at the prices f.o.b. British port. (At that date sterling and the West African currency were at par.) Costs per shift have also been worked out.

In Table 1, the estimated capital costs are entered in rows 1 to 9, and the operating costs per shift from other tables have been multiplied by the appropriate numbers of shifts shown in the column headings and entered in the relevant columns. Sources or methods of estimation for each row are entered in column n.

Before considering the implications of Tables 1 to 3, it is necessary to emphasize that these results depend on the assumptions described in Chapter 2, and might be different in different circumstances, an illustration of which will be given below.

As they stand, Tables 1 to 3 represent the factor cost situation in a West African country in mid-1967 and although there must be a margin of error, they are considered sufficiently accurate to enable ordinal comparisons to be made between different methods of operation and different scales of operation, and also to indicate the relative importance of different cost items.

A reservation must be made with regard to the estimated costs of distribution and advertising. It can be seen from column m, rows 22 and 26 of Table 1 that the cost of distribution and advertising amount to only 4.7 per cent of sales cost, whereas recently published figures for an actual Nigerian brewery, showed that these items in 1964 comprised 12 per cent of turnover.(23)

The cost of distribution in the models was based on minimal assumptions with regard to full loads and length of journeys. Consequently, estimates based on an actual market situation, together with a higher estimate for advertising expenditure such as 5 per cent instead of 4 per cent on turnover, are likely to raise the estimated cost of these items so reducing profits (row 35 of Table 1) to a more normal level.

In looking at capital costs in Table 1, the main point to be notices is that the estimated costs of stores and working capital together exceed the cost of machinery and transport equipment, and amount approximately to between half and two thirds of the total capital costs shown in row 1. Since working capital is based on two months operating costs rather than one, it may be an over-estimate in relation to normal operation. However, the need for adequate working capital when starting an undertaking must be emphasised.

The cost of oranges (row 10 of Table 1) is a very low proportion of total sales cost (row 33), being 3.1 per cent in case AI and 2.4 per cent in case DI. This means that the cost of oranges could double without having an appreciable effect on profit. However, orange prices appear to vary very greatly, and in 1966 according to a private source, the price paid to the grower in Bolivia was said to vary from 2d. to 5d. per lb. compared with 0.589d. per lb. (or 110s. per ton) assumed in this calculation. At 5d. per lb. the cost of oranges in Case AI would be £4,664 instead of £491 and there would be a net loss of £100 instead of a net profit of £4,073. It is thus not surprising that in Bolivia most orange drinks are made from imported concentrate.

It may be mentioned here that it is sometimes possible to stabilise the seasonal price of oranges bought from farmers by contract buying of the crop in advance.

The relative importance of various operating costs are more easily seen in Table 2, which shows various items in group totals which have been related to output expressed in hundred dozen bottles (row 1). Row 4 gives totals for raw materials and supplies. These constitute a very high proportion of total sales costs (row 20), ranging from 52 per cent in case AI to 79 per cent in case DIII.

Economies of Scale

Comparing like with like in row 21 of Table 2, reveals that the unit costs fall as the scale of output increases. The fall is greatest between cases A and B, and tapers off between cases C and D. The same result is expressed in terms of increasing returns to scale in row 36 of Table 1. The gross rate of return on capital doubles from 18 per cent in case AI to 36 per cent in case BI. There is a more moderate increase to 44 per cent in case CI. The slight fall between cases CI and DI is probably due to errors of rounding. At D the capping, labelling and bottle-washing machines become fully automatic, and although the unit cost curve appears to level off at this point, it would not be correct to expect unit costs for plants larger than D to increase. Further economies might accrue from larger fully automated units, and from the introduction of fully automatic juice extraction. Indeed, the calculations in Table 2 tend to disprove the assertion of Staley and Morse that bottled soft drinks belong to a group of industries in which "transfer costs of the finished products are high in relation to potential scale economies", and sufficiently high to inhibit the incentive to gain a moderate advantage by serving several markets from a central plant.(24) According to row 11 of Table 2 the cost of transportation (about 75 per cent of which is the cost of distribution) tends to decrease with increasing scale in cases II and III where vehicles are more fully utilised owing to all-year operation. This is due to the fact that transport is subject to its own economies of scale arising from the more economic use of larger vehicles. It can be seen from Table 16 that the load capacities of vehicles increase at a higher rate than their cost.(25) It must be emphasised that these results are influenced by the assumption that the average length of journey remains constant, while scale increases.

Confirmation for the effect of economics of scale leading to concentration in the soft drinks industry (of which orange squash is part) is provided by Kenya. There, between 1961 and 1963, "establishments fell from 21 to 18, persons engaged from 854 to 752, yet production rose from £1.1 million to £1.3 million, thus indicating a greater degree of concentration in the industry."(26)

However, it is possible that small or moderate sized firms might be viable in some circumstances. Obvious examples are island communities or areas which are isolated owing to bad communications. Alternatively, existing firms might be precluded from getting larger (and taking advantage of economies of scale) by lack of investment funds, which might be available to a new comer. Further, it is possible to attract customers by higher advertising expenditure and to attach them by means of specially efficient service or high quality of product.

Finally, a reference should be made to the very small soft drinks firms which flourish in developing countries. For example, according to the Industrial Survey, Nigeria, 1963, the soft drinks industry contained, (besides 15 larger firms) a large number of small producers of mineral waters, employing less than 10 persons.(27) Orange squash can also be made on a cottage scale. It is possible that such little firms survive by employing family members and charging very low prices to a limited number of customers.

Some information has been collected regarding equipment and other inputs required to produce 10 x 26.2/3 oz. bottles of orange squash per half day of 4 hours. This has not been included in the report mainly because at this level of output, it is not possible to prescribe the measures for maintaining the high standards of hygiene and quality which are necessary in the food industry.

Oranges or Compound or Both?

Row 21 of Table 2 shows that for scales B, C and D the lowest unit cost is achieved in case I where oranges only are processed for four months of the year. In all the models, the highest unit cost appears in case III, where no oranges are processed and compound is used all the year round.

This appears to be due to the predominant weight of the cost of raw materials and supplies (row 5 of Table 2) the unit cost of compound being considerably higher than that of oranges. In comparing case II with case I for each model the main source of saving on unit cost is due to running the plant all through the year instead of for four months, and in comparing case III with case II, additional savings result from dispensing with the equipment and labour required for orange processing. Except for "miscellaneous" (row 15) all the other unit costs in Table 2 are affected by these savings. However they are not large enough in aggregate to offset the increase in raw material costs between cases I, II and III except in model A. Here, certain unit cost items are exceptionally heavy in case I, for example, manpower (row 13) owing to the fact that one manager and two supervisors are assumed to be employed all the year round, and depreciation (row 19) because utilisation of equipment is lower than in other models. The impact of savings in these unit cost items is sufficiently heavy to reverse the trend observed in other models.

However, from the firm's point of view, the choice of model would be affected also by the initial investment, which varies from case to case. The initial investment is brought into the analysis through the rate of return. The gross return on capital, which is shown in row 36 of Table 1, is sales revenue (row 34) less total annual sales cost (row 33) expressed as a percentage of total capital costs shown in row 1. At all scales, the rate of return in case I is much lower than in the other two cases. This is to be expected because the equipment is only utilised for one third of the year, compared with the whole year in cases II and III. For scales B, C and D, the rate of return is higher in case II than in case III, while for scale A, the

rate of return is highest in case III. The commoner pattern is due to the cost saving resulting from using oranges rather than compound for a third of the year. For scale A, this effect is offset by a much greater proportionate fall in capital costs between cases II and III, when orange processing is eliminated. It should be remembered that the commoner pattern could be reversed if the price of oranges were higher. Also, if the orange season were longer, or if other citrus fruits could be processed so as to extend the production period to the whole year, or a large proportion of it, the rate of return for case I at each scale would be considerably higher.

The further possibility of processing enough juice during the orange season to keep the bottling line in operation throughout the year has not been fully investigated in this report. Additional investment would be necessary. For example, sufficient juice to run the bottling line in scale C could be processed by having twice the capacity of juice extracting machinery, as in case D, and running it on single shift during the first and fourth month of the orange season and on double shift during the two middle months. The necessary amount of juice with preservative added could then be stored in waxed wooden barrels in an air-conditioned storage chamber until required for use. Information about the quantities and costs of barrels required, storage space and the estimated cost of air conditioning equipment is given in Appendix I.

The main arguments in favour of using compound all the year round are the lower initial investment required and the greater simplicity of the process which obviates pasteurising, while the problem of variation in the raw material is obviated. In this report, it is assumed that the compound is imported, so that there is a continuous foreign exchange cost. This need not necessarily be the case, and in developing countries where the fruit processing industry is well established, firms engaged in large scale juice concentration or comminution may make compounds for the use of the soft drinks industry. Compounds comprise concentrated juices plus flavour, acid and colour,(28) while simple concentrated juice or comminuted bases(29) may also be used. Compounds etc. may require cool storage, depending on the circumstances. Some costing information for cool storage of the quantities mentioned in this report are given in Appendix I.

Given the factor costs assumed in this report, there appears to be a slight advantage in using fresh orange juice for part of the year despite the somewhat higher capital cost. The use of locally produced orange juice all the year round involving higher capital costs for air-conditioned storage and extra juice processing machinery might be justified by the saving in foreign exchange and the provision of extra employment opportunities. This is a suitable subject for social cost benefit analysis, which is outside the scope of this report.

The Effect of Taxation

Table 3 shows the effect of the taxation system in the West African country upon the results as calculated in Table 1. The industry has no Pioneer Status so that it is necessary to take account only of initial and annual capital allowances, when deducting from profits, tax at the rate of 8s. in the £1. The Table is self-explanatory with regard to rates of allowance.

Since the tax system operates at the same rates on each of the models, there is no change in the ordinal comparison. The inclusion of taxation in the models serves only to bring them a stage nearer to reality, and to act as a check on the calculation in general. A soft drinks firm operating on a fairly large scale in West Africa stated that they expect a return on capital

after tax from 25 to 30 per cent. The rates of return shown in row 11 are after tax and depreciation. They are thus high in relation to the firm's statement and suggest that errors of estimate have the cumulative effect of underestimating costs, and/or overestimating revenue.

Recommendations

The foregoing section serves to reinforce the opinion stated earlier in this report that the decision to set up an orange squash factory should be preceded by a very careful local investigation including a costing in terms of local factor costs and expected revenue. Blank spaces have been left in many of the tables to facilitate the task of anyone who wishes to make the attempt.

It should be stressed that the results as set out in Tables 1, 2 and 3 and discussed in this chapter assume a continuous output at an operating efficiency of 80 per cent and somewhat lower levels of overall efficiency as may be deduced from the utilisation factors given in columns c of Tables 4 to 7. Thus at scale C, the utilisation factors range from 36 per cent at the sieving machine to 72 per cent at the capping machine, so that the overall efficiencies range from 29 per cent to 58 per cent; indicating a not unduly optimistic level of performance. However, in reality a factory might produce at even lower rates in the early stages of production. In order to allow for such variations in output over time and for variations in income owing to the tax system, such as exemption from tax over an initial period in the case of a Pioneer Industry, the discounted cash flow method of appraising different investment projects should be used. This method has other advantages, a discussion of which is outside the scope of this report. It has not been used in this report since the ordinal comparison between the models would not be affected and because the absolute rates of return, which would be affected, are not thought to be very critical, at this stage.

Part II

Methodology

1. Sources of Information.

The information used in compiling this report has been gathered from firms (mainly British), research institutes including other departments of the Tropical Products Institute, British Government departments and overseas representatives, and from publications. The organisations which have supplied information used in the report, and published sources are listed in Appendix II.

In order to supplement the machinery makers' specifications as to the performance of machines and labour requirements and to secure additional facts, fairly detailed operational surveys and/or interviews were carried out at three British factories manufacturing soft drinks. As there is no firm in Britain engaged in the extraction of juice from oranges for the manufacture of squash, a detailed questionnaire was constructed with the intention of obtaining operational and costing information from overseas firms engaged in processing oranges for the manufacture of squash. The questionnaire could be filled in easily by someone with experience of industrial surveys or knowledge of the industry in question. However, it requires a skilled personal approach to secure the co-operation of a firm in an operational and financial survey, and, although some attempt was made to place questionnaires indirectly, it is not surprising that only one questionnaire was received from a firm manufacturing squash in West Africa. The information supplied in this questionnaire and several supplementary letters has been of great value, and together with published information relating to factor prices in the country in question, it has formed the basis of the costings and financial calculations included in this report, as well as serving as a guide to operating practice. The identity of this firm and the country in which it is situated are not disclosed in the report partly to avoid disclosing information which was given in confidence, and partly because in certain respects the models are fictional and it was desired to obviate giving the impression that they could be identified in their entirety in a particular country. However, since many of the costings such as the cost of transport from the West African port and the rent of land should be consistently related to a particular site, all values for such items pertain to the actual site of the factory, whose manager answered the questionnaire.

2. Methods of Calculation

The general concepts upon which the models have been based are outlined in Part I, pages 4-8. The following notes describe item by item how the tables were calculated. References are made to row numbers and column letters.

Table 1 Costs and economics of scale in the production of orange squash from natural orange juice and compound.

Most of the figures in this table are derived from other tables in the report; sources for each row are given in the final column n. More detailed explanations of certain items are given below.

Row 8 Installation and unforseens. Since it is impossible to foresee all the items of expenditure which are likely to occur and certain minor items are better left to the final planning stage, an allowance of 20 per cent of other capital costs has been included. This covers such items as land clearance, office equipment, port handling charges, handling equipment such as wheelbarrows or (for the larger models) conveyors.

Row 9 Working capital. The amount of working capital required at the outset has been based on two months' cash operating costs. The undertakings are assumed to operate on a cash basis so that the normal average period between payment for factors and receipts for the finished product might be of the order of three or four weeks, once the rhythm of production and distribution has been established.

Row 16 Maintenance on Machinery. An expert[31] has recommended that 5 per cent of annual sales should be used as a minimum for estimating this item. In the present context this method of estimation would yield anomalous figures, since less machinery is required in cases III for the same value of sales as in cases II. Therefore maintenance on machinery has been estimated as 20 per cent on the capital cost of machinery in cases I and 40 per cent in cases II and III. The fact that a stock of spare parts is allowed for in Tables 4 to 7 below does not eliminate maintenance as an operating cost item, because the parts should be charged to operations as they are used.

Row 26 Advertising. The figure of 4 per cent on sales was derived from a survey[31] of the fruit processing industry in India.

Row 27 Interest on working capital. A long established export and import firm gave 8 per cent per annum as a reasonable charge in the circumstances. As the case I models operate for only four months, interest is charged at the rate of 4 per cent to allow for partial closing down.

Row 28 Other costs. This is an allowance for items which may have been under-estimated or omitted[32]. For example, it might be necessary to have an extra employee, apart from the manager and supervisors, responsible for buying oranges.

Row 34 Sales revenue. The net delivered price of squash in a 26.2/3rds oz. bottle was taken to be 32.40d. including 6d. returnable deposit on the bottle. This estimate was based on information given in the questionnaire. A merchant operating in West Africa in this industry confirmed that it is correct to charge the same for squash made from oranges as for squash made from compound.

Table 2. Capital and operating costs per hundred dozen bottles of orange squash.

The figures in this table are derived by division from those in Table 1 and require no further explanation.

Table 3. The effect of Local Taxation on Net Profit, Rate of Return and Pay-Off Period.

In Table 3, the company tax system has been applied to the capital and revenue items derived in Table 1.

It appears that the soft drinks industry has not been accorded Pioneer Industry status, so it is assumed that there is no question of exemption from tax for an initial period.

The annual allowances at 5 per cent on buildings (row 2) and 10 per cent on plant (row 3) have been deducted from gross profit (row 1) to yield taxable adjusted gross profit in row 5. From the latter figure is deducted company tax at 8s. in the £1. to yield profit after tax in row 7. Row 8 shows net profit after depreciation and tax.

Tax allowances are given for capital expenditure in the year in which it is incurred. In this calculation this initial allowance is dealt with by deducting the tax avoided from total capital costs (row 9) to yield residual capital cost after allowances in row 10. The allowance on plant is made at the rate of 40 per cent, and that on buildings at the rate of 20 per cent. The tax avoided on these magnitudes is at the rate of 8s. in the £1. as before.

The initial allowances of 10 per cent on plant and 5 per cent on the cost of the buildings have been dealt with by deducting the tax avoided from the initial capital. The result is shown as residual capital in row 10.

The rate of return on residual capital is calculated after tax and depreciation and shows in row 11.

The pay-off period is calculated after tax and before depreciation on residual capital and shown in row 12. This method of assessing investments is regarded by Alfred and Evans(33) as open to less criticism than any of the methods other than the discounted cash flow.

Tables 4 to 7, Scales A, B, C and D. Quantities and Costs of Equipment and Stores. Quantities of Power, Floorspace and Labour.

Columns b, d, e and f. The information in these columns was collected from manufacturers of machinery and other equipment.

Columns c and h. The utilisation factor is the total throughput at each stage, as stated in the headings of each table on the left hand side, expressed as a percentage of the total capacity of the number of units required in each section (column h). The number of units in each section has chosen to yield utilisation factors in general not above 75 per cent, allowing a margin of extra capacity which could be utilised in practice by putting on extra operatives. For scales C and D the utilisation factor of the halving machine(s) has been allowed to rise above 75 per cent and in these cases the operative complements have been appropriately increased.

The steam jacketed pans (row 6), cold process syrup makers (row 8) and blending vessels (row 9) are made by the manufacturer, who gave information for this report, in two sizes only, namely 50 gallon and 100 gallon. The numbers of each item required for processing the throughput at each stage depends not only on the time required for processing but also on the time required for pumping the liquid into and out of the vessels. The pumps which are included in the specifications are capable of a delivery up to 1,000 gallons per hour; the rate assumed in the calculations being 400 gallons per hour. The estimated processing time for pasteurising approximately 30 gallons of orange juice at scale B is given below.

Operation	Minutes
Pumping juice in and out	9
Estimated time to raise 15 gal. of juice from 60°F to 190°F	14
Holding time	1
	24

One 50 gallon pan is thus adequate to deal with the throughput at both scales A and B.

In the case of syrup mixing pans the loading has been based on the machinery makers' claim(34) that these machines can process a quantity of syrup equal to twice this capacity in one hour*. There is in fact some excess capacity; e.g. at scale B, only approximately 70 gallons of syrup per hour have to be processed in the 50 gallon pan. At scale D an extra 100 gallon mixing pan has been allocated. This gives some additional capacity which might be used in conjunction with the highly productive bottling machine when using compound.

It is necessary to have one blending vessel in excess of the net capacity required for one batch of squash which is ready for bottling while the remainder is being prepared.

Column f and g. The prices of items of equipment f.o.b. United Kingdom port and delivered at the factory have been estimated by using information on the cost of packing and carriage to a United Kingdom port and sea freight given by machinery makers and other firms. In most cases the estimated f.o.b. value was 8 per cent above the ex factory price while the estimated c.i.f. value was 18 per cent above the ex factory price. Two per cent was added to the c.i.f. price to allow for internal transport to the factory. No allowance has been made for West African port dues or handling charges.

The f.o.b. and delivered prices of lorries are as stated by a firm which supplies lorries and operates transport in West Africa.

According to suppliers, the c.i.f. value of the bottles is about 137 per cent of the f.o.b. value.

The soft drinks industry in the country in question has not been declared a "pioneer" industry with exemption from import duty. However, machinery for the making of orange squash, boilers for industrial purposes and laboratory equipment enter duty free. The duty on imported lorries (rows 19 and 20) is 33.1/3rd per cent on the c.i.f. price, which partly explains the large margin between the f.o.b. and delivered prices. Part of the difference is due to the £200 cost of a locally made wooden body. The duty on bottles and closures is 33.1/3rd per cent on the c.i.f. value.

The cost of testing equipment (row 23) is not easy to estimate, since much of it consists of glass equipment of unpredictable durability, which may or may not be available for purchase in a developing country. Scrutiny of two independent assessments for plant and equipment for fruit processing factories in developing countries revealed that in both cases, the estimated requirements for laboratory equipment and supplies amounted to about 6 per cent of the value of processing machinery. This percentage, applied to the cost of processing machinery including juice extraction is the basis of the figures in row 23 of Tables 4 to 7.

The ex-factory British price (mid 1967) of various items of equipment required for the tests and the estimated c.i.f. West African values are given overleaf:

---

*Checking the times empirically was not possible because syrup mixing tends to be kept secret in British factories.

Two refractometers for testing the sugar content of syrup and squash.

	ex factory	c.i.f.
15° - 55°Brix	£18.25	£41.875 (air freight)
40° - 85°Brix	£22.50	

Set of glass apparatus for acid test.

ex factory	c.i.f.
£2.89	£3.81 (sea freight)

Set of Monier Williams apparatus for preservative test.

ex factory	c.i.f.
£23.28	£31.27 (sea freight)

A check was made to establish that the sums estimated in row 23 are sufficient to cover adequate quantities of the above apparatus both in use and in stock as well as a stock of chemicals and furniture, in countries where these items cannot be purchased locally.

Column 1. top. Labour requirements have been based upon machinery makers' recommendations, and upon information derived from surveys and the questionnaire, and are considered to be adequate to cover handling at all stages as well as productive work. It will be noticed that a complement of non-skilled operatives has been allowed in each case for handling finished goods (row 22). Transport operatives shown in rows 19 and 20 are not included in the totals (rows 30 to 32) because transport is costed separately in Tables 15 and 16. Sixteen operatives are allocated for this purpose at both scales C and D. The number has not been doubled in scale D (to allow for twice the output) because it is assumed that there is a gravity roller case conveyor for transporting packed bottles into the store. The item has not been costed separately since to do so would involve having an accurate scale plan of the factory which is not necessary at this stage. The cost is allowed for in row 8 of Table 1 (installation and unforeseens).

Table 8. Factory Floorspace and Site Area
Initial Cost of Buildings and Annual Cost of Repairs. Annual Rent of Land.

Table 21. Floorspace for Storage and Processing. Total Site Area.

The composition of the total building area is shown in detail in Table 21.

Row 1 of Table 21. The calculation of storage space rests on the assumptions outlined in Part I. An examination of the relation between the dimensions and weight of contents of standard orange boxes showed that about 40 lb. of oranges occupy 1 cu. ft. The space allowed for storing oranges is twice the net amount required to store in bins two days supply of oranges lying not more than 3 feet deep. The additional space is required to allow for handling and for the extra 4 per cent of fruit assumed to be wasted. Thus in case AI, two days supply is 375 lb. x 12.8 hours = 4,800 lb., so that the total space required would be $\frac{4,800 \times 2}{40 \times 3} = 80$ sq. ft.

This figure appears in Table 21 at 1c.

Rows 2 and 3 of Table 21. The total floorspace for production areas has been derived by multiplying the net floorspace totals shown in rows 17 and 18 of Tables 4 to 7 by a recommended factor of 3. (If an allowance is being made for expansion, the factor should be 5.)(35)

Rows 4 and 5 of Table 21. The calculation of storage space for bottles has been based on the assumptions that the area of the base of a carton holding 12 x 26.2/3rds oz. bottles is 10 in. by 13 in. Full bottles can be stacked 7 cartons high and empty bottles 6 cartons high. Storage space was estimated sufficient for a week's supply of empty and full bottles. The width and breadth of two cases in each direction was allowed for alley ways at scale A. The approximate areas for scale A are 230 sq. ft. for empties and 200 sq. ft. for full bottles.

Row 7 of Table 21. The maximum ground area occupied by buildings can be as low as 0.3 of the site area. In the present study the site area has been estimated by doubling the building area.(35)

Column d of Table 8. The cost of buildings in developing countries varies widely. The figure of £1.15s. per sq. ft., which has been used in the calculation was suggested by a firm of merchants and manufacturers with wide experience of the country for a simple building with a concrete floor and prefabricated roof using mainly locally produced materials. A figure of £5.3s. per sq. ft. was quoted by another firm in respect of a more elaborate soft drinks factory built in a neighbouring country during the 1960's using materials entirely imported from Britain.

Column e of Table 8. The cost of repairs at £12 per 1,000 sq. ft. was based on information given in the questionnaire. In addition there would be a small charge for insuring the building, for which no estimate has been made. As only one shift is being worked, no lighting cost has been included.

Column f of Table 8. The factory is assumed to be situated on an industrial estate, providing roads, drains, electricity, water and telephones, the current rent for which might be £100 per acre.

Table 9. Quantities and Costs of Materials per Shift for squash made from Fresh Orange Juice. (Scale A. 300 x 26.2/3rd oz. Bottles per Running hour.)

Column c. The quantities given here are based on an Indian recipe(11) for squash intended for commercial production.

Column e. The local prices of sugar, potassium metabisulphite (used for making the 9 per cent solution of sulphur dioxide) and oranges were taken from the questionnaire. Those of orange extract, NRS, and orange colour were based on a duty paid landed cost, calculated by the supplier, to which was added 2 per cent to allow for transport to the factory. The price of citric acid in column f was estimated from the f.o.b. value quoted by a supplier.

Import duties on various imported materials were 3½d. per lb. for sugar, 33.1/3rd per cent on the c.i.f. value for citric acid, orange colour and potassium metabisulphite and 50 per cent on the c.i.f. value of orange extract. The seasonal costs of raw materials shown in Table 1 can be derived from column f. of this table by multiplying by 80 shifts for scale A and by scale factors of 2, 4 and 8 for scales B, C and D respectively.

Table 10. Quantities and Costs of Materials per Shift for Squash made from Orange Compound (Case A. 300 x 26.2/3rd oz. Bottles per Running Hour.)

Column c. The quantities shown in this column are based on a recipe given by the firm which supplies orange compound. The original recipe allowed 4 lb. of sugar to 1 gallon of squash. This would give a squash of about 35° Brix. (The Brix scale denotes the percentage by weight of sugar in a solution.) As shown in the heading of row a. of Table 9. the natural orange squash is 45° Brix. Since customers would be unlikely to accept a squash made from compound less sweet than that made from fresh juice, the proportion of sugar was increased to 5.41 lb. per gallon of squash.(36) The sugar content of the two squashes is thus approximately the same.

Columns e. and f. The f.o.b. price and the duty paid landed cost of the tenfold orange compound are as stated by the supplier. An addition of 2 per cent has been made to cover transport from the port to the factory.

The ad valorem rate of duty on compound is 50 per cent on the c.i.f. value.

Table 11. Quantities and Cost of Supplies per Shift ((Scale A. 300 x 26.2/3rd oz. Bottles per Running Hour).

Columns c. and d. A 10 per cent loss of bottles was considered a reasonable allowance by members of firms with overseas experience. The cardboard containers and the closures are disposable.

Column f. The prices of containers and labels were taken from the questionnaire. The prices of bottles (see footnote 1 of Table 11) and of closures are based on information given by suppliers. The cost per bottle is 13.4d. If a deposit of 6d. is charged, the replacement cost is 7.4d.

The rate of duty on bottles and closures is 33.1/3rd per cent on the c.i.f. value.

Table 12. Quantities and Costs of Electric Power.

Column c. Kilowatt hours (kWh) have been based on the totals for horsepower (HP) of electric motors shown in column j of Tables 4 to 7. To allow for the fact that the machines do not have to run for the whole assumed running time of 6.4 hours per shift, in order to process the required throughput at each stage, the highest utilisation factor in each case (see columns c. of Tables 4 to 7) has been used to make a rough estimate for the period during which the machines actually run. These utilisation factors are 0.62 for scales A and B, 0.78 in scale C and 0.82 in scale D.

The 19.0 kWh for case AI (c.1 of Table 12) is derived from Table 4, (17.j.) as follows, assuming normal three phase supply.

4.785 HP x 0.62 (maximum utilisation factor) *
x 6.4 (running hours) = 19.0 kWh.

---

* A more accurate formula for estimating kWh from HP is kWh = (HP x 0.746) ÷ (PF x EF), where PF = power factor and EF = efficiency factor. The simpler formula, which may be used in cases where the power factor and efficiency factor are not known, as in this case, tends to underestimate electricity requirements.

Column d. Charges for electricity in the country are in the form of a two-part tariff, consisting of a monthly demand charge, based on the maximum demand by the consumer during the month; and a running unit charge. The relevant part of the monthly demand charge is given below.

Maximum demand in KVA	Fixed Charge per month s. d.	
Up to 10	30 0)	
11 to 25	27 6)	per KVA or part thereof
26 to 50	25 0)	

On the advice of a member of the accounts department of the London Electricity Board, the value for the KVA was assumed to be equal to that of the nearest 0.5 HP below the actual figure for horsepower as stated for each case in Tables 4 to 7. Thus in case AI, where the total HP is 4.785, the KVA is 4.5 and the monthly demand charge is 4.5 x 30s. or £6.75. Column f. The running unit charge is 3d. per unit in the area where the factory is situated.

Table 13. Quantities and Costs of Wood Fuel for Boilers

Table 22. Quantities of Water, Hot Water and Steam, Estimated Boiler Capacity.

Column c. of Table 13. These items have been derived from Table 22, which contains estimates of the British Thermal Units (B Th U's)* required for heating water used in various processes and for cleaning. The boilers are assumed to be in operation for eight hours a day in order to allow for cleaning which is done when processing machines are not running.

Steam boilers are necessary in all cases where orange juice is pasteurised (cases A to D, I and II), and a steam boiler is assumed to be used in case D III the largest plant making squash from compound only. Water boilers are assumed to be used in cases A to C, III.

Rows 16 to 18 of Table 22 shows the estimated B Th U's required for each process. In the case of fruit and bottle washing machines, B Th U's are estimated by multiplying the weight in lb. of hot water required per hour by the difference between the required temperature and 60°F, which is the assumed temperature of cold water (one gallon of water weighs 10 lb). In the case of steam jacketed pans, the B Th U's are estimated by multiplying the number of lb. of steam required by 1,000.** The resulting B Th U's are added to give the total B Th U's shown in rows 19 and 21. Rosw 20 and 22 of Table 22 show the approximate capacity of the boilers. A third must be added to the estimated B Th U's required, to estimate the capacity of the steam boilers in order to allow for the fact that a larger fuel compartment is required for burning wood than for coal. The approximate rating for the water boilers used in cases A III, B III and C III were supplied by the manufacturers.

---

* A B Th U is the quantity of heat required to raise the temperature of 1 lb. of water through 1°F.

**This results from the fact that 1,000 B Th U's of latent heat per lb. are required to convert water to steam.

The estimates for fuel required must also allow for the efficiency of the boilers which has been assumed to be 65 per cent. Thus, in Table 13, for case AI, the figure of 3,813,000 B Th U's per shift (c.1) is derived from the 309,800 B Th U's per hour shown in Table 22 (c.19) as follows:

$$\frac{309{,}800 \text{ B Th U's} \times 8 \text{ hours}}{0.65 \text{ (boiler efficiency)}} = 3{,}812{,}923 = 3{,}813{,}000 \text{ B Th U's}$$

Column d. The wood assumed to be used is a common one in the area having a calorific value of 5,500 B Th U's per lb, and weighing 26.67 lb. per cubic foot allowing for 13.5 per cent of moisture over the oven dry weight. The calorific value and the weight per cubic foot were divided into the figures in column c to estimate the quantity of wood required in cu. ft. Since the firm of the questionnaire used 128 cubic feet per production day, the figures in column d. appear to be under estimates. As the values involved are fairly low, no attempt at adjustment has been made.

Table 14. Quantities and Costs of Water for Processing

Column c. The method of estimating water required per shift for processing is shown in detail in rows 11 and 15 of Table 22, which is based largely on machinery makers' specifications for various processes itemised in rows 3 to 7 of Table 22. An allowance of 25 per cent on the estimated total requirements of water for squash and processing was made in rows 9 and 13 of Table 22 to cover water used for cleaning. No allowance was made for extra hot water since the major part of the cleaning work is assumed to be done during the 1.6 hours per shift when the machines are not running.

The estimated total requirements of water per shift for scale A, shown in row 10 of Table 22, ranging from 3,200 gal. to 6,500 gal. per shift are of the right order of magnitude, since the firm of the questionnaire which produced at the rate of about 460 bottles per running hour, was stated to use 5,000 gal. per shift of about six running hours. There is a dearth of relevant published information on water requirements for beverage production.

Column e. The price of 4s. per 1,000 gal. was based on a price of 3s.9d. given in a source relating to the West African country which prevailed in the area in 1961.

Table 15. Transport for Orange Collection Squash Distribution and Collection of Empty Bottles, Annual Cost of Hired Transport.

Empirical information on the real costs of transporting oranges from farms to the factory was limited to that in the questionnaire, which also contained a little information about the distribution of squash. British firms supplied further information on beverage distribution, and on the capacity and operating costs of transport vehicles. Using these facts in conjunction with certain assumptions, models have been constructed to show how transport costs might vary as the scale of operations increases.

Columns b. to c. of Table 15 demonstrate the demand for transport resulting from the given facts and assumptions.

Column d. The quantities of oranges to be moved are taken from Table 9, c.10 and include the 4 per cent allowance for waste. The quantities of squash are based on the daily outputs. The weight of one dozen 26.2/3rd oz. bottles of squash in a cardboard carton is about 40 lb. At 300 bottles per hour for 6.4 hours, the daily output is 160 dozen. 160 x 40 lb. = 2.86 tons.

Column e. In this column the weight of material to be moved is shown as the number of loads (or part loads) for the lorries whose number and capacity is shown in columns i. and j.

Column f. The average lengths of trips have been derived from the questionnaire, in which it was stated that a 3 ton lorry travelled 5,300 miles to collect 200 tons of oranges. This yields an average journey per ton of 26.5 miles. This average length of journey has been assumed to remain constant for each model although the quantity of oranges required doubles with each increase in the scale of operations. It can be shown that this assumption is realistic by comparing the acreage necessary to supply the oranges with the total area which might be covered to yield an average journey of 26.5 miles.

Although the yield of oranges per acre in Spain was stated(37) to range from 9.4 to 18.8, the yield in tropical areas was considered in 1960 to be about 5 tons per acre.

At a yield of 5 tons per acre the planted acreage required would range from 54 for case A to 432 to case D.

If it is assumed that each factory stands in the centre of a circle of land from which the oranges are collected, the average journey of 26.5 miles can be assumed to be equal to twice the radius of a circle whose area is half that of the whole area covered.

Let R be the radius of the larger circle

Let r be the radius of the smaller circle (= 13.25 miles)

$$\Pi R^2 = 2 \Pi r^2$$
$$\frac{R^2}{2} = \gamma^2$$
$$\sqrt{\tfrac{1}{2}R^2} = \gamma = 13.25 \text{ miles}$$
$$R = 19 \text{ miles approximately}$$

Then the area of the larger circle is $\Pi\, 19^2 = 1{,}130$ sq. miles.

It can thus be assumed that the two thirds of a square mile of plantation required to supply factory D can easily lie within the radius of 19 miles.

It is assumed in that in each case the factory is at the centre of a road system on which collections are made from depots on the road side. The average distance travelled tends to be equal to the average empirical journey (26.5 miles) and the maximum distance from the factory also tends to be equal to this figure. It is assumed that there are sufficient lorries to bring in daily requirements of fruit and that each time a lorry goes out on a trip it can collect a full load from a depot, and that each lorry can make four trips per shift.

Similar facts and assumptions relate to the distribution of squash. It was stated in the questionnaire that a 3 ton lorry delivers about 200 dozen bottles (20 oz.) up to 70 miles away. Again, it was assumed that the average length of trip (there and back), and also the most distant point reached both tend to equal 70 miles. It is also assumed that lorries occupied in delivering squash bring back empties on the return journey so that they cannot be used for collecting oranges while thus occupied.

Column g. The concept of the 'vehicle day' was introduced by an accountant employed by a large British firm of soft drinks manufacturers. Each of the firms lorries is assumed to be available for a number of vehicle days which is less than the number of working days in the year by the number of days required for maintenance. In this calculation the number of vehicle days per lorry is assumed to be 210 per year; i.e. 240 minus 30 days for maintenance. The amount of work to be done by the lorries can also be expressed in vehicle days as indicated in column 1.

Column h. This column shows the number of depots for oranges or bottles of squash assumed to be visited once a week in each case. At scale B, the same quantity of oranges is collected from twice the number of depots as in A. At scale C. twice as much is collected from the same number of depots as in B. At scale D. the same amount is collected from twice the number of depots. Similar principles apply to squash distribution.

Column i. This column shows the annual demand for transport expressed in vehicle days, which are the product of the number of weeks worked, the number of depots visited each week and the amount of work involved in each visit.

Columns j. and k. The models to which column j refers are of a type manufactured in Britain for export only. The one with a capacity of 3.3 tons was the smallest quoted for by a firm which both sells vehicles and operates transport undertakings in West Africa, and which gave advice on estimating transport requirements. A representative of the manufacturer of the vehicles stated that the carrying capacity can be estimated by deducting from the maximum gross weight of the vehicle, the weight of the chassis and the weight of the body.

13,640 lb. - (5,140 lb. = 1,120 lb.) = 7,380 lb. = 3.3 tons.

The capacity of the larger vehicle was estimated similarly.

Given the capacities of the two types of lorry used, the appropriate number and type for each purpose, (orange collecting and squash distribution) required in the different models were determined as follows: (a) by allowing sufficient capacity in vehicle days (210 per vehicle) to cover the requirements in vehicle days as shown in column i. and (b) by allowing sufficient capacity in tons to carry the loads shown in column d.

Within the framework outlined above surplus capacity was kept down to a minimum, and it was assumed that requirements in excess of the capacity allocated in Table 15 would be met by hiring transport.

Thus in case AI, where the plant operates for 80 shifts a year, the one lorry is available for at least 80 days a year (assuming that maintenance is done outside the operating period) and since according to column i, only 60 vehicle days are needed to collect oranges and distribute squash, it is assumed that the one vehicle is sufficient for both purposes. In case A II 120 vehicle days are required for squash distribution and 20 for orange collection. Again it is assumed that one lorry is sufficient.

In case BI, 80 vehicle days are required for distributing squash (column i. 5) so that the one lorry allocated in this case would be fully loaded. On the other hand only 40 vehicle days are required for collecting oranges. Transport is therefore assumed to be hired for this purpose. In case B III, the two lorries are occupied for only 240 vehicle days out of a total of 420, so that there is surplus capacity available for other purposes.

Cases C and D are treated similarly to case B. i.e. transport is assumed to be hired for the collection of oranges, in case I there is just enough transport for the distribution of squash, and in cases II and III there is some excess capacity.

Column l. This column shows the distances in miles covered in carrying out the various tasks.

Column m. This column shows the requirements for transport in ton miles.

Column n. The price of 8d. per ton mile was suggested by the British firm which operates transport undertakings in the country, and is also quoted in a published local source.

The totals in this column related to the cost of hiring transport for orange collection and squash distribution only. There would be an additional charge for bottle collection. The rate for return journeys is not known. However, as squash distribution and empty bottle collection are assumed to be done by the firms' own lorries, this omission is not important. It should be remembered when comparing these figures with the costs shown in Table 16, that the latter allow for empty bottle collection as well.

Table 16. Cost of Owned Transport.

This table, which is based on Table 15 and on information supplied by the British firm operating transport in the country is largely self-explanatory.

Total annual mileage. These items shown in rows 3, 16, 29 and 41 are derived from column l of Table 15, according to the assumptions stated above. Thus in case A I, the 7,720 miles is composed of 2,120 miles for orange collection and 5,600 miles for squash distribution. In case A II, 18,920 miles equals 2,120 miles plus 16,800 miles.

Tables 17 to 20. Complements and Costs for Management, Supervision and Labour.

Column e. The rates of earnings used in computing the figures in this column relate to mid - 1967, which were derived from the questionnaire are set out below.

Type of Personnel	Earnings £ (mid 1967)	Period
Managerial	119.0	month
Supervisory (semi-technical)	20.5	month
Semi-skilled	10.0	month
Non-skilled	1.2	week

The employers' contribution to a fund to provide benefits in case of unemployment at the rate of 3d. for each complete 5s. of wages, has been allowed for approximately by multiplying the earnings costs per shift based on the above rates of earnings by 1.05. There is no such provision for managerial staff.

Columns d, h and l. The numbers of employers in this column are taken from Tables 4 to 7, and exclude transport operatives who are dealt with in Table 16.

In cases I and II, the personnel is subdivided into permanent and temporary according to whether they are retained on the pay roll all the year round or are employed only during the orange season. Managerial, supervisory and semi skilled staff are assumed to be on the payroll permanently since they would be difficult to replace if dismissed at the end of the orange season. Non-skilled operatives and clerical staff are assumed to be employed seasonally where they are employed in connection with orange processing.

Table 21. Floorspace for Storage and Processing; Site Area.

This table has been explained in conjunction with Table 8 which deals with the estimated cost of factory floorspace and site area (see pages 24-25).

Table 22. Quantities of Hot Water and Steam. Estimated Boiler Capacity.

This table has been explained in conjunction with Table 13 which deals with quantities and costs of wood fuel for boilers (see page 27).

Appendix I

Additional Information

Varieties of Oranges.

Tressler and Joslyn(38) list the following more important commercial varieties of oranges:

Homosassa
Parson Brown
Hamlin
Jaffa
Pineapple
Valencia
Ruby Blood
Navel (Washington Navel; Riverside Navel; Bahia).

Of the above, the Valencia is said to grow in almost every citrus processing country in the world. An expert has stated that the best varieties for juice processing are the Valencia, Blanca (main Spanish variety), Jaffa, Hamlin and Pineapple, while the Navel is totally unsuitable because bitter elements are contained in the separate segment within the orange.

The variety of orange trees found growing in most tropical countries is frequently unknown. Any oranges which might be used for processing should be assessed for quality and local agricultural departments should be asked for advice on this problem and also on the source of suitable stock if planting is being considered.

Alternative Juice Extraction Machines for Scale D

On page 6 in Chapter 2 of this report, reference is made to a small scale automatic juice extracting machine. This machine which is made in Italy would probably prove to be economic if used at scale D.

With this machine the fruit is placed on an inclined tray either by hand or by conveyor and enters the machine in four parallel lines. The fruit is pressed automatically inside the machine, and the juice flows from the machine into a linked automatic helicoidal sifter for separation of the juice from the seeds or pulp. All essential parts are made of stainless steel except the parts which come into contact with the fruit while the juice is being extracted, which are made of nylon.

The essential details follow:

Capacity of juice extractor	13,000 fruits per hour 2.32 tons per hour (if 10 fruit weigh 4 lb.)
Power for juice extractor	3.5 H.P.
Power for sifter	0.5 H.P.
Floor space for extractor and sifter	67 sq. ft.
Price of extractor and sifter f.o.b. Genoa, February 1968	4,090,000 lire
Price of above at October 1967 exchange rate £1 = 1,733 lire	£2,360
Estimated price delivered at factory mid-1967	£2,648

This fully automatic line would replace hand-operated equipment costing £3,252 (Table 7, i, 3, 4, 5) and 27 semi-skilled operatives. On the other hand, mechanical supervision and maintenance would have to be taken into account.

There is also a British line of automatic juice extraction machinery with a capacity of 1.25 tons of oranges per hour, which cost about £3,480 f.o.b. UK in mid-1967. In this process, which requires one semi-skilled operator and two unskilled labourers, the orange is quartered and the peel separated from the pulp with great precision. The extra cost is not justified unless it is intended to sell or utilise the peel.

A Small-scale Plate Heat Exchanger for Pasteurising Juice

At the time of going to press, a British firm announced the introduction of a plate-heat exchanger which could be used to pasteurise as little as 15 gallons of juice per hour. This process would be subject to more precise control than the steam-jacketed pan. Formerly, only models of large capacity were available. Further information can be supplied on request.

The Use of Oil or Hard Fuel instead of Wood

Since adequate supplies of wood are not available in all developing countries, the effect on costs of using oil or hard fuel instead of wood has been investigated for scale D, cases I and II.

Both capital and operating costs are affected. In the first instance for burning oil or hard fuel, a boiler having only three quarters of the capacity of a wood burning boiler is required. On the other hand, in the case of oil extra equipment and floorspace are required. Operating costs are higher in the case of oil. The operating cost for coal or coke is not dealt with in this report.

The 16 H.P. boiler assumed at scale C, cases I and II is adequate for scale D cases I and II if oil or hard fuel is burned.

The respective prices delivered at the factory of these two boilers are £1,222 and £1,471;* (see Tables 6 and 7). If hard fuel were burned there would thus be a saving in capital cost of £249.

If oil were burned, it would be necessary to have in addition a steam injector type oil burner and an oil tank on stand to allow gravity feed. Including certain other items, this would cost (at October 1967 prices) £338 f.o.b. UK or £372 delivered at factory. The total cost of the 16 H.P. oil-fired boiler would be £1,394 f.o.b. UK or £1,594 at factory, involving a net addition to equipment cost of £123, (£1,594 - £1,471). The net floorspace required would be about 50 sq. ft. instead of 25 sq. ft.

The oil requirements may be calculated from Table 13, assuming the calorific value of oil of medium viscosity to be 19,000 B Th U's per lb., its specific gravity to be 0.85 and the price per gallon to be 3s. 8d.

For case DI, the estimated annual cost of oil is £1,086 compared with £163 for wood and for case DII, the annual cost of oil is £1,533 compared with £230; (see column f. of Table 13).

---

*By October, 1968, the ex-factory UK prices of boilers had increased by 6 per cent compared with October 1967.

The effect of using oil on estimated total annual sales cost may be considered in relation to rows 20 and 21 of Table 7. The cost of oil per 100 dozen bottles is £1.06 in case DI and £0.50 in case DII. The effect on depreciation is of a minor order and has not been calculated.

It should be stressed that owing to scale economies, the increase in operating cost would be greater for the smaller models.

Cool Storage for Compound.

There is some difference of opinion as to whether compound requires to be kept in a cool store. The type assumed in this report contains a preservative, and cool storage is considered unnecessary if small stocks and quick turnover can be maintained.

This section contains some details on the cost of providing cool storage for compound in case the circumstance should make it necessary.

The compound is packed in 10 gallon polythene-lined metal drums, which can be stacked in three tiers. The storage room should be 6.5 feet high to allow for ease of movement. At scale A an estimated area of 110 sq. ft. with a volume of 715 cu. ft. would be required. For scale D, 813 sq. ft. and 5,280 cu. ft. are required.

In order to maintain the required temperature of around 45°F. with an external temperature of 90°F. proper insulation of the building would be required as well as air conditioning equipment. A rough estimate of the cost of insulation material and equipment would be £2 per cu. ft. for scale A and £0.75 per cu. ft. for scale D. These are f.o.b. UK prices in August, 1968. The estimated c.i.f. charge would be 15 per cent. Allowing an extra 2 per cent on the c.i.f. price for delivery to the factory, the estimated additional costs for cool storage of compound would be as follows:

	Scale A	Scale D
Volume in cu. ft.	715	5,280
F.o.b. cost	£1,430	£3,961
C.i.f. cost	£1,644	£4,555
Cost at factory	£1,677	£4,646

For the smallest store the operating costs would depend on 1½ HP for the compressor plant which runs continuously and 1½ HP for lighting and fans. The lights would not be in continuous use. The corresponding quantities for scale D are 7½ HP and 2½ HP. According to Table 4, the total power required without storage or lighting is 4.785 HP in case AII and 1.660 in case AIII, and according to Table 7, the corresponding figures are 41.375 HP in case DII and 29.250 HP in case DIII. The increase in power requirements would thus be substantial.

Cool Storage for Orange Juice

It has been stated above on page 18 that a possible alternative to using compound when oranges are not in season, would be to instal twice as much orange processing equipment, and by working double shift for two months of the orange season and single shift for the other two months, to process enough orange juice to last the bottling department all through the year.

To construct a model of this type having the output of scale C, the necessary information for doubling the orange processing capacity is given

in Table 7 for scale D. However, it would also be necessary to provide cool storage capacity for eight months supply of orange juice to be used outside the harvest season which would increase both capital and operating costs.

The juice could be stored in wax lined oak barrels containing 40 gallons. The storage chamber would again have to be insulated to maintain a suitable temperature of 45°F. The estimates for equipment given in this note are based on the assumption that a week is allowed for the juice to cool down and that the store is not opened frequently.

The price of once-used wax-lined whiskey casks fluctuates between £3 and £4 each.

Early in 1968, the price per barrel delivered on the West Coast of Africa was £3.5, which becomes £3.57 if 2 per cent is added for local transport. For scale C, 38,950 gal. of juice would be required to operate for 160 days or 8 months, so that 974 barrels would be needed initially. Assuming that the barrels are stacked in 3 tiers, the necessary area for scale C would be 1,970 sq. ft. with a volume of 12,800 cu. ft.

The storage area could be divided into compartments, using three or four machines for the whole area, which could be shut down or used for storing squash. For the above area 20 HP would be required for air conditioning equipment and 4 HP for fans and lighting. The estimated f.o.b. cost for insulating material and equipment would be £0.75 per cu. ft. The estimated cost of cool storage insulation and equipment (in addition to the basic cost of the building) plus the cost of barrels would be:

	Scale C
Area in sq. ft.	1,970
Volume in cu. ft.	12,800
F.o.b. cost	£9,604
C.i.f. cost	£11,045
Cost at factory	£11,266
Cost of extra floorspace*	£3,447
974 barrels at £3.57	£3,477
Net addition to capital costs	£18,190

According to Table 2, the total capital cost for scale CII is £74,760; the net addition to capital costs estimated above amounts to 24 per cent.

There would also be an increase in working capital owing to carrying stocks of juice for eight months.

Operating costs would have to be recalculated to take account of working double shift for two months during the orange season.

Changes in prices between mid-1967 and end 1969.

Prices of machinery and materials exported from the U.K. and used in the manufacture of orange squash have increased since mid-1967. However, the reader may adjust the prices given in the tables by means of percentages to obtain a more accurate up-to-date version of capital costs and some operating costs which will be adequate for a rough assessment of the feasibility of

*Area of 1,970 sq. ft. at £1.75 per sq. ft.; (see Table 8).

producing squash. If, on this basis, a decision to proceed is reached, machinery makers can be asked to provide an up-to-date specification.

Since mid-1967, the UK price level of machinery other than electrical, has risen by about twenty per cent and that of transportation equipment by about eight per cent. Both these percentages refer to exports from UK. The price level on the UK home market of glass containers, including bottles, has risen by a little over two per cent while that of "other glass products (except containers)" including laboratory equipment, rose by about six per cent.

It is necessary to remember that these percentages represent average changes and the increases charged by individual firms may be higher or lower. The firm which gave prices for orange compounds said that the price of ten-fold orange compound (f.o.b. UK port) has risen from 27s.6d. per gal. to 30s.6d. per gal. an increase of 11 per cent.

Liner freight rates between Britain and West Africa on machinery have increased by 21 per cent or by approximately the same rate as machinery. In order to estimate the current cost of machinery delivered at the factory in West Africa, it would consequently suffice to increase the appropriate prices in the tables by 20 per cent while allowing for devaluation of the pound sterling which took place in November 1967. Prior to that date, sterling and the West African currency were at par and since then the exchange rate has been UK £1 = West African £0.85712.

The freight rate on bottles has increased by 26 per cent and that on compound by 21 per cent. These percentages can also be used for adjusting the values of the items in question.

Appendix II

Acknowledgements

Besides colleagues at the Tropical Products Institute many individuals and organisations were asked to supply the information or advice on which this report is based and the help of all is gratefully acknowledged. (However, none of the models represents the entire practice of any particular firm.) There follows a list of firms and other outside organisations which gave information actually used in the report. The list is subdivided according to the main subject of information given, and in the case of manufacturers, the product or activity in which we were interested is stated in brackets below the name of the firm. Names of individuals are given if they made particularly valuable contributions.

A full list of suppliers of machinery, equipment and other requirements of the soft drinks industry is published monthly in the Soft Drinks Trade Journal.

Machinery

A. P. V. Exports,
(Orange juice processing plant)
Manor Royal,
Crawley,
Sussex.
Mr. T. F. S. Cooper

Brierley, Collier & Hartley Ltd.,
(Fruit processing machinery)
Bridgefield Street,
Rochdale,
Lancashire.
Mr. M. G. Cottingham.

C. P. Equipment Ltd.,
(Centrifugal pumps)
Mill Green Road,
Mitcham,
Surrey.

Fratelli Indelicato,
(Fruit processing machinery)
Via Finocchiare Aprile 110,
Giarre,
Catania,
Sicily.

George S. Clayton Ltd.,
(Engineers)
Barnaby Works,
Bourne Road,
Bexley,
Kent.
Mr. S. Barrel

George S. Clayton Ltd.,
(Fruit processing and bottling machinery)
St. Anne's Works,
St. Anne Street,
Limehouse,
London, E.14.
Mr. J. S. Clayton Marshall

Ideal Standard Ltd.,
(Water boilers)
Ideal Home,
Great Marlborough Street,
London, W.1.

J. & E. Hall Ltd.,
(Refrigerating machinery)
Dartford Iron Works,
Dartford,
Kent.
Mr. A. C. Worsfold

Morgan Fairest Ltd.,
(Bottle labelling machines)
Fairway Works,
Carlisle Street,
Sheffield, 4.

Robert Kellie & Son Ltd.,
(Fruit Processing machinery)
40 East Dock Street,
Dundee.

Walter W. Coltman & Co.
(Boilers) Ltd.,
(Steam boilers)
Great Central Road,
Loughborough.
Mr. C. E. Onions

Prices, Costing and Taxation

Armstrong Cork Co. Ltd.,
(Bottle closures)
Export Service Department,
Kingsbury,
London, N.W.9.

Barnet & Foster Ltd.,
(Essences and Compounds)
Queensbridge Road,
London, E.8.
Mr. R. F. Smith

Board of Inland Revenue,
Somerset House,
London, W.C.2.
Mr. S. Lonsdale

Board of Trade,
Hillgate House,
35 Old Bailey,
London, E.C.4.

The Crown Cork Co. Ltd.,
(Bottle closures)
Southall,
Middlesex.

Dagenham Motors,
(Commercial vehicles)
374 Ealing Road,
Alperton.
Mr. Effingham

Electricity Corporation of Nigeria,
York House,
99, Westminster Bridge Road,
London, S.E.1.

Forster's Glass Company Ltd.,
(Bottles and containers)
Atlas Glass Works,
P.O. Box No. 41,
St. Helens,
Lancashire.

Gallenkamp (A. G. & Co. Ltd.),
(Laboratory apparatus)
6 Christopher Street,
London, E.C.2.

Glass Manufacturer's Federation,
19 Portland Place,
London, W.1.

John Holt Ltd., (Head Office)
(Export Dealers, Transportation)
India Buildings,
Liverpool, 2.
Mr. M. A. Mair

John Holt Ltd., (Export)
(Export dealers)
4th Floor, Moor House,
London Wall,
London, E.C.2.

LEB (London Electricity Board)
46 New Broad Street,
London, E.C.2.
Mr. Roberts

The Metal Box Co.,
(Glass and plastic containers)
37, Baker Street,
London, W.1.

Ministerio de Agricultura,
Ganadera y Colonizacion,
Asesores Britanicos en
Agricultura Tropical,
La Paz,
Bolivia.
Mr. C. E. Johnson

Ministry of Trade and Industry,
Western Group of Provinces of
Nigeria,
Ibadan,
Nigeria.

Motor Transport,
(Transport periodical)
Dorset House,
Stamford Street,
London, S.E.1.

Schweppes Ltd.,
(Soft drinks manufacturers)
Research Laboratory,
Garrick Road,
London, N.W.9.
Mr. W. T. Watkins

Schweppes,
(Soft drink distributors)
Grosvenor Road,
St. Albans,
Herts.
Mr. Williams

Shell International
Petroleum Co. Ltd.,
(Fuel oil)
Shell Centre,
London, S.E.1.

United Glass Ltd.,
Kingston Road,
Staines,
Middlesex.

Processing and quality control

Abeokuta Industrial Institute,
(Blaize Memorial)
P.O. Box 226,
Abeokuta,
Nigeria.
Mr. S. A. Martin

Beecham Food & Drink Division,
(Soft drinks manufacturers)
Beecham House,
Great West Road,
Brentford,
Middlesex.
Dr. V. L. S. Charley

British Food Manufacturers Research
Association,
Leatherhead.
Miss H. Goodall and
Mr. J. Anderson

Food Machinery Association,
14 Suffolk Street,
London, S.W.1.

J. Mills & Sons,
Mineral Water Manufacturers,
Ossory Road,
London, S.E.1.
Mr. Mills

K. Chellaram & Sons (London) Ltd.,
(Exporters and Importers)
6 Charterhouse Buildings,
London, E.C.1.
Mr. Vaugham

Moore Bros. (Swanscombe) Ltd.,
(Mineral Water Manufacturers)
Swanscombe,
Kent.
Mr. Moore

The National Association of Soft Drinks Manufacturers Ltd.,
The Gatehouse,
2 Holly Road,
Twickenham,
Middlesex.
Mr. Penn

National College of Food Technology,
Weybridge.

T. Giusti & Son,
(Food Machinery Engineers)
210 York Way,
London, N.7.

Taylor & Co.,
Soft Drinks Manufacturers,
215A London Road,
Staines.
Mr. and Mrs. Taylor

University of Bristol,
Department of Agriculture and Horticulture,
Research Station,
Long Ashton,
Bristol.
Miss M. Leach and
Dr. A. Pollard

W. J. Bush & Co. Ltd.,
Essence Distillers,
Ashgrove,
London, E.8.
Mr. Raith

Water Pollution Research Board,
Elder Way,
London Road,
Stevenage.

1. "Fruit and Vegetable Processing Technology", by D. K. Tressler and M. A. Joslyn. (The Avi Publ. Co., Westport, Connecticut, 1961), p.142.

2. Charley, V. L. S., Intern. Bottler & Packer, 1963, 37, 92.

3. "Citrus Products: Chemical Composition and Chemical Technology", by J. B. S. Braverman (Interscience, New York, 1949), p.302.

4. "Industrial Processing of Citrus Fruit", by Z. Berk (UNIDO Food Industry Studies No. 2, United Nations, New York, 1969), pp.4-6.

5. "Modern Small Industry for Developing Countries", by E. Staley and R. Morse (McGraw Hill, New York, 1965), p.114.

6. "Fruit, A Review", Commonwealth Secretariat (H.M.S.O., London, 1967), p.138.

7. S.I. 1964, No. 760, Food & Drugs, Composition and Labelling; The Soft Drinks Regulations 1964 (H.M.S.O., London, 1964), p.1.

8. Charley, V. L. S., Food Technology, 1963, 17, 7.

9. "Technical Conversion Factors for Agricultural Commodities", ed. P. V. Sukhature (F.A.O., Rome, 1960).

10. "The Soft Drinks Bottler", by G. A. Beattie (Mineral Water Trade Review Co. Ltd., London, 1950), Vol. I, p.77.

11. "Preservation of Fruits and Vegetables", by G. Lal, G. S. Sidappa, and G. L. Tandon (Indian Counc. of Agr. Research, New Delhi, 1960), p.116.

12. Ref. 11, p.12.

13. "Industrial Development: A Guide for Accelerating Economic Growth", by M. D. Bryce (McGraw Hill, New York, 1960) p.127.

14. Ref. 13, p.125.

15. Ref. 11, p.20.

16. "Chemistry and Technology of Citrus, Citrus Products and Byproducts", Agric. Res. Service Agricultural Handbook No. 98 (U.S. Dep. of Agr., 1962), p.53.

17. "Beverages: Soft Drink Bottlers' Handbook", by J. Z. Ruiz (All Americas Publishers Service Inc., Chicago and Mexico DF), p.64.

18. Ref. 3, p.175.

19. "Recent Advances in Fruit Juice Production", by V. L. S. Charley and others (Tech. Comm. No. 21, Commonw. Bureau Hortic. & Plantation Crops, 1950), p.77.

20. Ref. 11, p.106.

21. Ref. 7, p.12.

22. Ref. 11, p.110.

23. "Industrialization in an Open Economy: Nigeria 1945-1966", by P. Kilby (Cambridge Univ. Press, 1969), p.99.

24. Ref. 5, p.114.

25. "Economics of Private Truck Transportation", by W. Y. Oi and A. D. Hunter Jr. (Wm. C. Brown Co. Publishers, Dubuque, Iowa, 1965), pp.130, 131.

26. Kenya Census of Industrial Production (Min. of Economic Planning & Development, 1965), p.42.

27. Industrial Survey of Nigeria, 1963 (Federal Office of Statistics, Lagos, 1966), p.13.

28. Ref. 10, p.26.

29. Ref. 4, p.57.

30. Ref. 13, p.133.

31. "Fruit and Vegetable Preservation and Canning", Small Industry Analysis & Planning Report No. 15 (Min. of Commerce & Industry, New Delhi, 1958), pp.44 and 92.

32. Ref. 13, p.136.

33. "Appraisal of Investment Projects by Discounted Cash Flow: Principles and Some Short Cut Techniques", by A. M. Alfred and J. B. Evans (Chapman & Hall, London, 2nd ed., 1965), p.2.

34. "The Jusfrute Book", by G. I. Adcock (Jusfrute Ltd., Gosford, N.S.W., 2nd ed.), p.68.

35. Ref. 10, Vol. II, p.142.

36. Ref. 34, p.133.

37. "Citrus Industry of Spain", by J. H. Burke (Foreign Agric. Report No. 56, U.S. Dep. of Agr., 1961), p.17.

38. Ref. 1, p.839.

Table I

Costs and Economies of Scale in the Production of Orange Squash from Natural Orange Juice and Compound

Values in Sterling: mid-1967

		SCALE A Throughput per running hour 50 gal. Squash 300 x 26.2/3 oz. bottles			SCALE B Throughput per running hour 100 gal. Squash 600 x 26.2/3 oz. bottles			SCALE C Throughput per running hour 200 gal. Squash 1,200 x 26.2/3 oz. bottles			SCALE D Throughput per running hour 400 gal. Squash 2,400 x 26.2/3 oz. bottles			Sources
		80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	
	a	b	c	d	e	f	g	h	i	j	k	l	m	n
1	Capital Costs - Total	22,000	23,000	18,700	35,800	40,200	35,600	66,900	74,800	67,500	138,000	150,000	140,000	Sum of rows 2 to 9
2	Buildings: orange processing) syruping and bottling)	1,500	1,500	-	2,780	2,780	-	5,200	5,200	-	10,100	10,100	-	Col. d. of Table 8
3	Syruping and bottling	-	-	1,000	-	-	2,000	-	-	3,600	-	-	6,900	Col. d. of Table 8
4	Machinery: orange processing) syruping and bottling)	4,460	4,460	-	5,720	5,720	-	10,400	10,400	-	23,900	23,900	-	Col. i. of Tables 4-7
5	Syruping and bottling	-	-	1,670	-	-	2,490	-	-	5,200	-	-	16,800	Col. i. of Tables 4-7
6	Lorries	1,870	1,870	1,870	1,870	3,740	3,740	2,600	5,190	5,190	5,190	7,780	7,780	Col. i. of Tables 4-7
7	Stores	4,410	4,850	4,300	8,310	8,880	8,230	16,400	17,500	16,400	33,400	35,800	34,400	Col. i. of Tables 4-7
8	Installations and Unforeseens	2,450	2,540	1,770	3,740	4,220	3,290	6,920	7,650	6,090	14.500	15.500	13.200	20% on sum of rows 2 to 7
9	Working Capital	7,680	7,780	8,130	13,400	14,900	15,900	25,400	28,900	31,000	50,500	57,300	61,500	2 months cash, operating costs (row c)
	Annual Operating Costs													
	Raw Materials and Supplied													
10	Squash - Oranges	491	491	-	982	982	-	1,960	1,960	-	3,930	3,930	-	Col. f. of Table 9
11	Other ingredients	5,830	5,830	-	11,700	11,700	-	23,300	23,300	-	46,600	46,600	-	Col. f. of Table 9
12	Squash - using compound	-	20,200	30,300	-	40,500	60,700	-	80,900	121,000	-	162,000	243,000	Col. f. of Table 10
13	Bottles	474	1,420	1,420	947	2,840	2,840	1,890	5,680	5,680	3,790	11,400	11,400	Col. f. of Table 11
14	Containers, closures and labels	1,830	5,480	5,480	3,660	11,000	11,000	7,310	21,900	21,900	14,600	43,900	43,900	Col. f. of Table 11
	Maintenance													
15	Buildings	10	10	7	19	19	14	36	36	25	69	69	47	Col. e. of Table 8
16	Machinery	891	1,780	668	1,140	2,290	996	2,070	4,150	2,080	4,780	9,570	6,720	I. 20% of row 4 II and III 40% of rows 4 or 5
	Power, Fuel and Water													
17	Electricity	46	77	47	49	82	49	164	345	271	425	1,020	896	Col. g. of Table 12
18	Wood fuel for boiler	52	64	18	52	64	18	100	124	35	163	230	101	Col. f. of Table 13
19	Water, for processing and cleaning	50	82	48	58	107	73	60	117	85	87	193	159	Col. e. of Table 14
	Transportation													
20	Hired transport for oranges	-	-	-	79	-	-	158	-	-	316	-	-	Col. n. of Table 15
21	Collection and distribution by owned transport	1,060	1,490	1,450	1,130	2,980	2,900	1,540	4,050	3,950	3,250	7,050	6,320	Table 16
22	Same, net of depreciation	594	868	828	664	1,740	1,650	891	2,320	2,220	1,960	4,450	3,730	Row 21 - row 32
	Manpower													
23	Labour (excluding transport)	929	1,640	1,320	1,460	3,010	2,520	2,480	4,220	3,450	4,030	5,250	3,820	Tables 17-20
24	Management and Supervision	1,940	1,940	1,690	1,940	1,940	1,690	2,460	2,460	1,940	4,410	4,410	1,940	Tables 17-20
	Miscellaneous													
25	Rent of land	4	4	3	7	7	5	14	14	9	26	26	18	Col. f. of Table 8
26	Advertising	829	2,490	2,490	1,660	4,980	4,980	3,320	9,950	9,950	6,640	19,900	19,900	4% on sales: row 34
27	Interest on working capital	307	622	651	536	1,190	1,288	1,020	2,310	2,480	2,020	4,590	4,820	II and III 8% on row 9
28	Other Costs	1,400	4,240	4,440	2,440	8,110	8,670	4,620	15,800	16,900	9,190	31,300	33,500	(10% on sum of rows (10 to 26 excluding 21
29	Total Annual Operating Costs	15,700	47,300	49,400	27,300	90,400	96,400	51,900	176,000	188,000	103,000	349,000	374,000	Sum of rows 10 to 28
	Depreciation													
30	Buildings	75	75	50	139	139	99	260	260	180	504	504	345	5% of row 2 or 3
31	Machinery	446	446	167	572	572	249	1,040	1,040	520	2,390	2,390	1,680	10% of rows 4 and 5
32	Lorries	468	623	623	468	1,250	1,250	650	1,730	1,730	1,300	2,600	2,600	33.1/3% or 25% of row 6
33	Total Annual Sales Costs	16,700	48,400	50,300	28,500	92,400	98,000	53,800	179,000	191,000	107,000	354,000	378,000	
34	Sales Revenue	20,700	62,200	62,200	41,500	124,000	124,000	82,900	249,000	249,000	166,000	498,000	498,000	32.4d. per bottle
35	Net Profit(1)	4,070	13,800	11,900	12,900	32,000	26,400	29,100	70,200	58,000	58,000	144,000	119,000	row 34-row 33
36	Gross Return on Capital per cent	18	60	64	36	80	74	44	94	86	43	95	85	row 35/row 1 x 100

Source:

See text pages 20-21

Footnotes

(1) It is probable that the net profit and, consequently, return on capital is over-estimated, owing to under-estimation of the costs of advertising and distribution. (See text page)

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Capital and Operating Costs per hundred dozen bottles of orange squash

Values in sterling: mid-1967

		Scale A 300 bottles per running hour			Scale B 600 bottles per running hour			Scale C 1,200 bottles per running hour			Scale D 2,400 bottles per running hour.		
		80 shifts oranges I	80 shifts oranges 160 shifts compound II	240 shifts compound III	80 shifts oranges I	80 shifts oranges 160 shifts compound II	240 shifts compound III	80 shifts oranges I	80 shifts oranges 160 shifts compound II	240 shifts compound III	80 shifts oranges I	80 shifts oranges 160 shifts compound II	240 shifts compound III
1	Annual output in hundred dozen bottles	128	384	384	256	768	768	512	1,540	1,540	1,020	3,070	3,070
	a	£ b	£ c	£ d	£ e	£ f	£ g	£ h	£ i	£ j	£ k	£ l	£ m
	Capital Costs												
2	Total	22,400	23,000	18,700	35,800	40,200	35,600	66,900	74,800	67,500	138,000	150,000	140,000
3	Per hundred dozen bottles	175.0	59.9	48.8	140.0	52.4	46.3	131.0	48.7	44.0	134.0	49.0	45.7
	Annual Operating Costs												
	Raw Materials and Supplies												
4	Total	8,620	33,400	37,200	17,200	66,900	74,500	34,500	134,000	149,000	69,000	268,000	298,000
5	Per hundred dozen bottles	67.3	87.1	97.0	67.3	87.1	97.0	67.3	87.1	97.0	67.3	87.1	97.0
	Maintenance												
6	Total	901	1,790	675	1,160	2,310	1,010	2,110	4,180	2,110	4,850	9,640	6,760
7	Per hundred dozen bottles	7.0	4.7	1.8	4.5	3.0	1.3	4.1	2.7	1.4	4.7	3.1	2.2
	Power, Fuel and Water												
8	Total	148	223	113	159	253	140	324	586	391	675	1,440	1,160
9	Per hundred dozen bottles	1.2	0.6	0.3	0.6	0.3	0.2	0.6	0.4	0.3	0.7	0.5	0.4
	Transportation												
10	Total	594	868	826	743	1,740	1,650	1,050	2,320	2,220	2,270	4,450	3,730
11	Per hundred dozen bottles	4.6	2.3	2.2	2.9	2.3	2.2	2.0	1.5	1.4	2.2	1.4	1.2
	Manpower												
12	Total	2,870	3,590	3,010	3,400	4,960	4,200	4,940	6,680	5,400	8,440	9,650	5,770
13	Per hundred dozen bottles	22.5	9.3	7.8	13.3	6.5	5.5	9.6	4.3	3.5	8.2	3.1	1.9
	Miscellaneous												
14	Total	2,540	7,360	7,580	4,640	14,300	14,900	8,970	28,000	29,300	17,900	55,800	58,400
15	Per hundred dozen bottles	19.8	19.2	19.7	18.1	18.6	19.4	17.5	18.2	19.1	17.5	18.2	19.0
	Annual Operating Costs(1)												
16	Total	15,700	47,300	49,400	27,300	90,400	98,400	51,900	176,000	188,000	103,000	349,000	374,000
17	Per hundred dozen bottles	122.0	123.0	129.0	107.0	118.0	128.0	101.0	114.0	123.0	101.0	114.0	122.0
	Depreciation												
18	Total	989	1,140	840	1,180	1,960	1,600	1,900	3,030	2,430	4,190	5,490	4,620
19	Per hundred dozen bottles	7.7	3.0	2.2	4.6	2.5	2.1	3.8	2.0	1.6	4.1	1.8	1.5
	Annual Sales Costs(1)												
20	Total	16,700	48,400	50,300	28,500	92,400	98,000	53,800	179,000	191,000	107,000	354,000	378,000
21	Per hundred dozen bottles	130.0	126.0	131.0	111.0	120.0	128.0	105.0	116.0	124.0	105.0	115.0	123.0

Source

Table 1

Footnotes

(1) See footnote (1) of Table 1

The values quoted in this table have been rounded to three significant figures.

Table 3

The Effect of Local Taxation on Net Profits, Rate of Return and Pay-off Period

Values in Sterling: mid-1967

		Scale A 300 bottles per running hour			Scale B 600 bottles per running hour			Scale C 1,200 bottles per running hour			Scale D 2,400 bottles per running hour		
		80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £	80 shifts oranges I £	80 shifts oranges 160 shifts compound II £	240 shifts compound III £
	a	b	c	d	e	f	g	h	i	j	k	l	m
1	Gross Profit (Row 34-29 of Table 1)	5,060.0	14,900.0	12,800.0	14,100.0	34,000.0	28,000.0	31,100.0	73,200.0	60,400.0	62,800.0	149,000.0	124,000.0
	Annual Allowances												
2	Buildings 5.0 Per Cent on Row 2 of Table 1	75.2	75.2		139.0	139.0		260.0	260.0		504.0	504.0	
3	Plant 10 Per Cent on Rows 4, 5 and 6 of Table 1	632.0	632.0	354.0	759.0	946.0	623.0	1,300.0	1,560.0	1,040.0	2,910.0	3,170.0	2,460.0
4	Total Annual Allowances Row 2 + 3	708.0	708.0	354.0	898.0	1,090.0	623.0	1,560.0	1,820.0	1,040.0	3,420.0	3,680.0	2,460.0
5	Taxable Adjusted Gross Profit (Row 1-4)	4,350.0	14,200.0	12,400.0	13,200.0	32,900.0	27,400.0	29,500.0	71,400.0	59,400.0	59,400.0	145,000.0	121,000.0
6	Company Tax at 8s. in the £ (Row 5 x 4)	1,740.0	5,690.0	4,960.0	5,290.0	13,200.0	11,000.0	11,800.0	28,600.0	23,700.0	23,800.0	58,200.0	48,600.0
7	Profit After Tax (Row 1-6)	3,320.0	9,240.0	7,800.0	8,830.0	20,800.0	17,100.0	19,300.0	44,700.0	36,700.0	39,100.0	90,900.0	75,300.0
8	Net Profit After Depreciation and Tax (Row 7 - row 30, 31 and 32 of Table 1)	2,330.0	8,100.0	6,960.0	7,650.0	18,900.0	15,500.0	17,300.0	41,600.0	34,200.0	34,900.0	85,400.0	70,700.0
9	Total Capital Costs (Row 1 of Table 1)	22,400.0	23,000.0	18,700.0	35,800.0	40,200.0	35,600.0	66,900.0	74,800.0	67,500.0	138,000.0	150,000.0	140,000.0
10	Total Residual Capital(2) Costs after Allowances	21,900.0	22,600.0	18,600.0	35,300.0	39,500.0	35,200.0	66,000.0	73,600.0	66,900.0	135,000.0	148,000.0	139,000.0
11	Return on Capital (Row 8 as percentage of 10)	10.6 11	35.9 36	37.6 38	21.7 22	47.7 48	43.9 44	26.3 26	56.6 57	51.2 51	25.7 26	57.8 58	50.9 51
12	Pay-off Period (Row 10 divided by row 7)	6.60 6½	2.43 2½	2.37 2½	3.99 4	1.90 2	2.06 2	3.42 3½	1.65 1¾	1.82 2	3.47 3½	1.62 2¾	1.84 2

Sources

Table 1
See text pages 21-22

Footnotes

(1) This table illustrates the effect of a country's tax system on profit. The actual magnitude of gross profits and return on capital after tax are likely to be over-estimated, and pay-off periods are likely in reality to be longer. (See page 21 of text).

(2) Tax avoided as a result of initial allowances which are 10% for buildings and 15% for plant has been calculated at 8s. in the £ and deducted from total capital costs in row 9.

The values quoted in this table have been rounded to three significant figures.

Table 4

Scale A: Quantities and Costs of Equipment and Stores. Quantities of Power, Floorspace and Labour

Throughput per running hour

375 lb. of sorted oranges
150 lb. of juice
50 gal. of squash
300 x 26.2/3 oz. bottles

Alternative modes of operating

I 80 shifts a year using natural orange juice
II 80 shifts a year using natural orange juice and
160 shifts a year using orange compound
III 240 shifts a year using orange compound

Values in sterling: mid-1967.

	List of Processes, Equipment and Stores	Capacity of one Unit: Maximum throughput per running hour	Utilisation factor: Per cent	Electric Motors: H.P. Per Unit	Floor Space per Unit: Square feet	Price of each Unit: f.o.b. U.K. port £	Price of each Unit: delivered at factory (estimate) £	Number of Units required in Section	Cost of Equipment in Section £	Power per Section (row d. x h.) H.P.	Net Floor-space for Equipment (row e. x h.) Square feet	Labour Requirement: Management	Labour Requirement: Supervisory	Labour Requirement: Semi-Skilled	Labour Requirement: Non-Skilled	Labour Requirement: Clerical
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
	Processing Equipment															
	Juice Extraction															
1.	Fruit washer	...	...	0.50	18.80	810	903	1	903	0.50	18.80	-	-	-	1	-
2.	Sorting table	-	-		15.00	-	...	1	...	-	15.00	-	-	-	2	-
3.	Halving machine	4,800 fruits 1,920 lb.	20	0.75	4.17	292	330	1	330	0.75	4.17	-	-	-	1	-
4.	Juice extractor, double headed	1,500 fruits 600 lb.	62	0.75	4.81	233	259	1	259	0.75	4.81	-	-	-	2	-
5.	Juice separator	120 lb. juice	62	0.25	4.00	84	94	2	188	0.50	8.00	-	-	-	2	-
6.	Steam jacketed pan and pump	50 gal.(1)		0.125 + 0.50	7.25	448	500	1	500	0.62	7.25	-	-	1	-	-
7.	Sub-total Juice/Extraction	-	-	-	-	-	-	-	2,180	3.12	58.00	-	1	1	8	1
	Syruping and Bottling															
8.	Cold process syrup-maker agitator, filter and pump	50 gal.(1)		0.33 + 0.33 + 0.50	8.56	566	631	1	631	1.16	8.56	-	-)	1	-	-
9.	Blending vessel with stirring unit	50 gal.(1)		0.125	4.00	210	235	2	470	0.25	8.00	-	-)		-	-
10.	Filling machine, 6-spout	810 bottles 135 gal.	37	-	3.75	184	205	1	205	-	3.75	-	-	-	1	-
11.	Capping machine	480 bottles	62	-	-	56	62	1	62	-	-	-	-	-	1	-
12.	Labelling table	-	-	-	15.00	-	-	1	-	-	15.00	-	-	-	1	-
13.	Bottle washing machine	700 bottles	43	0.25	8.75	143	159	1	159	0.25	8.75	-	-	-	8	-
14.	Sub-total, syruping and bottling	-	-	-	-	-	-	-	1,530	1.66	44.10	1	1	1	11	1
	Alternative Heating Units															
15.	Steam boiler, and feed pump	9 H.P.(1)	-	-	16.00	675	748	1	748	-	16.00	-	-	-	1	-
16.	or Water boiler with cylinder	80 gal.(1)	-	-	4.00	121	144	1	144	-	4.00	-	-	-	1	-
	Equipment Totals															
17.	All processes I and II (rows 7 + 14 + 15)	-	-	-	-	-	-	-	4,460	4.78	118.00	1	2	2	20	2
18.	Syruping and bottling III (rows 14 + 16)	-	-	-	-	-	-	-	1,670	1.66	48.10	1	1	1	12	1
	Transport Equipment															
19.	Lorry I	3.3 tons(1)	-	-	-	822	1,870	1	1,870	-	-	-	-	1	1	-
20.	II and III	3.3 tons(1)	-	-	-	822	1,870	1	1,870	-	-	-	-	1	1	-
	Stores															
21.	Bottles	26.2/3 oz.(1)	-	-	-	4.31 per gross	8.04 per gross	400 gross	3,220	-	-	-	-	-	-	-
22.	Packaging, cartons	12(1) bottles	-	-	-	-	1.20 per dozen	400 dozen	480	-	-	-	-	-	4	-
23.	Testing equipment and materials	-	-	-	-	-	-	-	287	-	-	-	-	1	-	-
24.	Spare parts I		-	-	-	-	-	-	445	-	-	-	-	-	-	-
25.	II	-	-	-	-	-	-	-	890	-	-	-	-	-	-	-
26.	III	-	-	-	-	-	-	-	334	-	-	-	-	-	-	-
	Stores - Totals															
27.	All processes I (rows 21 to 23 + 24)	-	-	-	-	-	-	-	4,410	-	-	-	-	1	4	-
28.	All processes II (rows 21 to 23 + 25)	-	-	-	-	-	-	-	4,850	-	-	-	-	1	4	-
29.	Syruping and bottling III (rows 21 to 23 + 26)	-	-	-	-	-	-	-	4,300	-	-	-	-	1	4	-
	Total Labour Force															
	Excluding transport															
30.	All processes I	-	-	-	-	-	-	-	-	-	-	1	2	3	24	2
31.	II	-	-	-	-	-	-	-	-	-	-	1	2	3	24	2
32.	Syruping and bottling III	-	-	-	-	-	-	-	-	-	-	1	1	2	16	1

Sources.
See text pages 22-24

Footnotes

(1) Capacity or size only.
- Nil, negligible or not applicable.
... Figures not available.
--- Sub-total.

The values quoted in this table have been rounded to three significant figures.

Table 5

Scale B: Quantities and Costs of Equipment and Stores. Quantities of Power, Floorspace and Labour

Throughput per running hour
750 lb. of sorted oranges
300 lb. of juice
100 gal. of squash
600 x 26.2/3 oz. bottles

Alternative modes of operating
I 80 shifts a year using natural orange juice
II 80 shifts a year using natural orange juice and 160 shifts a year using orange compound
III 240 shifts a year using orange compound

Values in sterling, mid-1967

	List of Processes, Equipment and Stores	Capacity of one Unit: Maximum throughput per running hour	Utilisation factor: Per cent	Electric Motors: H.P. Per Unit	Floor Space per Unit: Square feet	Price of each Unit: f.o.b. U.K. port £	Price of each Unit: delivered at factory (estimate) £	Number of Units required in Section	Cost of Equipment in Section £	Power per Section (row d. x h.) H.P.	Net Floor-space for Equipment (row e. x h.) Square feet	Labour Requirement: Management	Supervisory	Semi-Skilled	Non-Skilled	Clerical
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
	Processing Equipment															
	Juice Extraction															
1.	Fruit washer	...	...	0.50	18.80	810	903	1	903	0.50	18.80	-	-	-	2	-
2.	Sorting table	-	-	- -	15.00	-	...	2	...	-	30.00	-	-	-	4	-
3.	Halving machine	4,800 fruits 1,920 lb.	39	0.75	4.17	292	330	1	330	0.75	4.17	-	-	-	1	-
4.	Juice extractor, double headed	1,500 fruits 600 lb.	62	0.75	4.81	233	259	2	518	1.50	9.63	-	-	-	4	-
5.	Juice separator	120 lb.	62	0.25	4.00	84	94	4	376	1.00	16.00	-	-	-	4	-
6.	Steam jacketed pan and pump	50 gal.(1)		0.125 + 0.50	7.25	448	500	1	500	0.62	7.25	-	-	1	-	-
7.	Sub-total Juice Extraction	-	-	-	-	-	-	-	2,630	4.38	85.80	-	1	1	15	2
	Syruping and Bottling															
8.	Cold process syrup-maker, agitator, filter and pump	50 gal.(1)		0.33 + 0.33 + 0.50	7.25	566	631	1	631	1.16	7.25	-	-)	1	1	-
9.	Blending vessel with stirring unit	50 gal.(1)		0.125	4.00	210	235	3	705	0.38	12.00	-	-)			
10.	Filling machine, 8-spout	1,080 bottles	55	-	4.50	227	253	1	253	-	4.50	-	-	-	1	-
11.	Capping machine, hand-operated, on table	480 bottles	62	-	-	56	62	2	124	-	-	-	-	-	2	-
12.	Labelling table	-	-	-	15.00	-	...	2	...	-	30.00	-	-	-	2	-
13.	Bottle washing machine	1,200 bottles	50	0.33	33.00	567	632	1	632	0.330	33.00	-	-	-	16	-
14.	Sub-total, Syruping and Bottling								2,340	1.86	86.80	1	1	1	22	2
	Alternative Heating Units															
15.	Steam boiler and feed pump I and II	9 H.P.(1)	-	-	16.00	675	748	1	748	-	16.00	-	-	-	1	-
16.	Water boiler with cylinder III	80 gal.(1)	-	-	4.00	121	144	1	144	-	4.00	-	-	-	1	-
	Equipment Totals															
17.	All processes (rows 7 + 14 + 15) I and II	-	-	-	-	-	-	-	5,720 ...	6.24	189.00	1	2	2	38	4
18.	Syruping and bottling (rows 14 + 16) III	-	-	-	-	-	-	-	2,490	1.86	90.80	1	1	1	23	2
	Transport Equipment															
19.	Lorry I	3.3 tons(1)	-	-	-	822	1,870	1	1,870	-	-	-	-	1	1	-
20.	II and III	3.3 tons(1)	-	-	-	822	1,870	2	3,740	-	-	-	-	2	2	-
	Stores															
21.	Bottles	26.2/3 oz.(1)	-	-	-	4.31 per gross	8.04 per gross	800 gross	6,430	-	-	-	-	-	1	-
22.	Packaging, cartons	12(1) bottles	-	-	-	-	1.20 per dozen	800 dozen	960	-	-	-	-	-	8	-
23.	Testing equipment and materials	-	-	-	-	-	-	-	343	-	-	-	-	1	-	-
24.	Spare parts I	-	-	-	-	-	-	-	572	-	-	-	-	-	-	-
25.	II	-	-	-	-	-	-	-	1,140	-	-	-	-	1	-	-
26.	III	-	-	-	-	-	-	-	498	-	-	-	-	1	-	-
	Stores - Totals															
27.	All processes (rows 21 to 23 + 24) I	-	-	-	-	-	-	-	8,310	-	-	-	-	1	9	-
28.	All processes (rows 21 to 23 + 25) II	-	-	-	-	-	-	-	8,880	-	-	-	-	2	9	-
29.	Syruping and bottling (rows 21 to 23 + 26) III	-	-	-	-	-	-	-	8,230	-	-	-	-	2	9	-
	Total Labour Force															
	Excluding transport															
30.	All processes I	-	-	-	-	-	-	-	-	-	-	1	2	3	47	4
31.	II	-	-	-	-	-	-	-	-	-	-	1	2	4	47	4
32.	Syruping and bottling III	-	-	-	-	-	-	-	-	-	-	1	1	3	32	2

Sources.
See text pages 22-24

Footnotes

(1) Capacity or size only.
- Nil, negligible or not applicable.
... Figures not available.
Sub-total or alternative total.

The values quoted in this table have been rounded to three significant figures.

Table 6

Scale C: Quantities and Costs of Equipment and Stores. Quantities of Power, Floorspace and Labour

Throughput per running hour

1,500 lb. of oranges, sorted
600 lb. of juice
200 gal. of squash
1,200 x 26.2/3 oz. bottles of squash

Alternative modes of operating

I 80 shifts a year using natural orange juice
II 80 shifts a year using natural orange juice and 160 shifts a year using orange compound
III 240 shifts a year using orange compound

Values in sterling, mid-1967

	List of Processes, Equipment and Stores	Capacity of one Unit: Maximum throughput per running hour	Utilisation factor: Per cent	Electric Motors: H.P. Per Unit	Floor Space per Unit: Square feet	Price of each Unit: f.o.b. U.K. port £	Price of each Unit: delivered at factory (estimate) £	Number of Units required in Section	Cost of Equipment in Section (row g. x h.) £	Power per Section (row d. x h.) H.P.	Net Floor-space for Equipment (row e. x h.) Square feet	Labour Requirement: Management	Supervisory	Semi-Skilled	Non-Skilled	Clerical
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
	Processing Equipment															
	Juice Extraction															
1.	Fruit washer	4,000 lb.	37	0.75 + 1.0	82.50	1,350	1,500	1	1,500	1.750	82.50	-	-	-	3	-
2.	Sorting table	-	-	-	15.00	-	...	4	...		60.00	-	-	-	8	-
3.	Halving machine	4,800 fruits 1,920 lb.	78	0.75	4.20	292	330	1	330	.750	4.17	-	-	-	3	-
4.	Juice extractor double-headed	1,500 fruits 600 lb.	62	0.75	4.81	233	259	4	1,036	3.00	19.30	-	-	-	8	-
5.	Sieving machine	1,680 lb. juice	36	1.00	6.17	470	522	1	522	1.00	6.17	-	-	-	3	-
6.	Steam jacketed pan and pump	100 gal.(1)		0.25 + 0.50	8.56	659	734	1	734	0.75	8.56	-	-	1	-	-
7.	Sub-total Juice Extraction	-	-	-	-	-	-	-	4,130	7.25	181.00	-	2	1	25	4
	Syruping and Bottling															
8.	Cold process syrup-maker agitator, filter and pump	100 gal.(1)		0.50 + 0.50 + 0.50	8.56	691	770	1	770	1.50	8.56	-	-)	2	-	-
9.	Blending vessel with stirring unit	100 gal.(1)		0.25	5.44	265	295	3	885	0.75	16.30	-	-)		-	-
10.	Filling machine, 8-spout	1,080 bottles	55	-	4.50	227	253	2	506	-	9.00	-	-	-	2	-
11.	Capping machine semi-automatic	840 bottles	72	1.0	6.00	351	392	2	784	2.00	12.00	-	-	-	2	-
12.	Labelling machine semi-automatic	1,800 bottles	67	0.75	9.00	513	571	1	571	0.75	9.00	-	-	-	1	-
13.	Bottle washing machine semi-automatic	2,400 bottles	50	3.50	52.20	1,350	1,500	1	1,500	3.50	52.25	-	-	-	16	-
14.	Sub-total, syruping and bottling		-	-	-	-	-	-	5,020	8.500	107.00	1	2	2	21	4
	Alternative Heating Units															
15.	Steam boiler and feed pump I and II	16 H.P.(1)	-	-	22.60	1,060	1,220	1	1,220	-	22.60	-	-	-	1	-
16.	Water boiler with cylinder III	100 gal.(1)	-	-	6.00	156	182	1	182	-	6.00	-	-	-	1	-
	Equipment Totals															
17.	All processes (rows 7 + 14 + 15) I and II	-	-	-	-	-	-	-	10,400	15.80	310.00	1	4	3	47	8
18.	Syruping and bottling (rows 14 + 16) III	-	-	-	-	-	-	-	5,200	8.50	113.00	1	2	2	22	4
	Transport Equipment															
19.	Lorry I	6.8 tons(1)	-	-	-	1,170	2,600	1	2,600	-	-	-	-	1	1	-
20.	II and III	6.8 tons(1)	-	-	-	1,170	2,600	2	5,190	-	-	-	-	2	2	-
	Stores															
21.	Bottles	26.2/3 f. oz.(1)	-	-	-	4.31 per gross	8.04 per gross	1,600 gross	12,900	-	-	-	-	-	2	-
22.	Packaging, cartons	12 bottles(1)	-	-	-	-	1.20 per dozen	1,600 dozen	1,920	-	-	-	-	-	16	-
23.	Testing equipment and materials	-	-	-	-	-	-	-	622	-	-	-	-	1	-	-
24.	Spare parts I	-	-	-	-	-	-	-	1,040	-	-	-	-	1	-	-
25.	II	-	-	-	-	-	-	-	2,070	-	-	-	-	2	-	-
26.	III	-	-	-	-	-	-	-	1,040	-	-	-	-	2	-	-
	Stores – Totals															
27.	All processes (rows 21 to 23 + 24) I	-	-	-	-	-	-	-	16,400	-	-	-	-	2	18	-
28.	All processes (rows 21 to 23 + 25) II	-	-	-	-	-	-	-	17,500	-	-	-	-	3	18	-
29.	Syruping and bottling (rows 21 to 23 + 26) III	-	-	-	-	-	-	-	16,400	-	-	-	-	3	18	-
	Total Labour Force															
	Excluding transport															
30.	All processes I	-	-	-	-	-	-	-	-	-	-	1	4	5	65	8
31.	II	-	-	-	-	-	-	-	-	-	-	1	4	6	65	8
32.	Syruping and bottling III	-	-	-	-	-	-	-	-	-	-	1	2	5	40	4

Sources.
See text pages 22-24

Footnotes

(1) Capacity or size only.
– Nil, negligible or not applicable.
... Figures not available.
--- Sub-total or alternative total.

The values quoted in this table have been rounded to three significant figures.

Table 7

Scale D: Quantities and Costs of Equipment and Stores. Quantities of Power, Floorspace and Labour

Throughput per running hour
3,000 lb. of sorted oranges
1,200 lb. of juice
400 gal. of squash
2,400 x 26.2/3 oz. bottles of squash

Alternative modes of operating
I 80 shifts a year using natural orange juice
II 80 shifts a year using natural orange juice and
160 shifts a year using orange compound
III 240 shifts a year using orange compound

Values in sterling, mid-1967

	List of Processes, Equipment and Stores	Capacity of one Unit	Utilisation factor	Electric Motors	Floor Space per Unit	Price of each Unit		Number of Units required in Section	Cost of Equipment in Section (row g. x h.)	Power per Section (row d. x h.)	Net Floor-space for Equipment (row e. x h.)	Labour Requirement				
		Maximum throughput per running hour	Per cent	H.P. Per Unit	Square feet	f.o.b. U.K. port £	delivered at factory (estimate) £		£	H.P.	Square feet	Management	Supervisory	Semi-Skilled	Non-Skilled	Clerical
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
	Processing Equipment															
	Juice Extraction															
1.	Fruit washer	4,000 lb.	75	0.75 + 1.00	82.50	1,350	1,500	1	1,500	1.75	82.50	-	-	-	6	-
2.	Sorting table	-	-	-	15.00	-	...	8	...	...	120.00	-	-	-	16	-
3.	Halving machine	4,800 fruits 1,920 lb.	82	0.75	4.17	292	330	2	660	1.50	8.33	-	-	-	6	-
4.	Juice extractor, double headed	1,500 fruits 600 lb.	62	0.75	4.81	233	259	8	2,070	6.00	38.50	-	-	-	16	-
5.	Sieving machine	1,680 lb. juice	71	1.00	6.17	470	522	1	522	1.00	6.17	-	-	-	5	-
6.	Steam jacketed pan and pump	50 gal.(1)	-	0.125 + 0.50	7.25	448	500	3	1,500	1.88	21.80	-	-	1	2	-
7.	Sub-total Juice Extraction		-	-	-	-	-	-	6,280	12.10	277.00	1	4	1	51	8
	Syruping and Bottling															
8.	Cold process syrup-maker agitator, filter and pump	100 gal.(1)	-	0.50 + 0.50 + 0.50	8.56	691	770	3	2,310	4.50	25.70	-	-)	4	-	-
9.	Blending vessel with stirring unit	100 gal.(1)	-	0.25	5.44	265	295	5	1,480	1.25	27.20	-	-)		-	-
10.	Filling machine, 18 head	560 gal.	71	1.00 + 1.50	22.00	3,510	3,910	1	3,910	2.50	22.00	-	-	1	-	-
11.	Capping machine fully automatic	3,600 bottles	67	1.00	8.00	1,190	1,300	1	1,300	1.00	8.00	-	-	1	-	-
12.	Labelling machine fully automatic	4,800 bottles	50	1.00 + 1.50	24.50	1,740	1,850	1	1,850	2.50	24.50	-	-	1	-	-
13.	Bottle washing machine fully automatic	3,600 bottles	67	17.50	50.00	4,800	5,360	1	5,360	17.50	50.00	-	-	1	7	-
14.	Sub-total, Syruping and Bottling	-	-	-	-	-	-	-	16,200	29.25	157.00	1	2	8	7	8
	Alternative Heating Units															
15.	Steam boiler and feed pump I and II	20 H.P.(1)	-	-	25.00	1,270	1,470	1	1,470	-	25.00	-	-	-	1	-
16.	Steam boiler and feed pump III	6 H.P.(1)	-	-	10.60	580	590	1	590	-	10.60	-	-	-	1	-
	Equipment Totals															
17.	All processes I and II	-	-	-	-	-	-	-	23,900	41.40	560.00	2	6	9	59	16
18.	Syruping and bottling III	-	-	-	-	-	-	-	16,800	29.30	188.00	1	2	8	8	8
	Transport Equipment															
19.	Lorry I	6.8 tons(1)	-	-	-	1,170	2,600	2	5,190	-	-	-	-	2	2	-
20.	II and III	6.8 tons(1)	-	-	-	1,170	2,600	3	7,780	-	-	-	-	3	3	-
	Stores															
21.	Bottles	26.2/3 fl. oz.(1)	-	-	-	4.31 per gross	8.04 per gross	3,200 gross	25,700	-	-	-	-	-	2	-
22.	Packaging, cartons	12 bottles(1)	-	-	-	-	1.20 per dozen	3,200 dozen	3,840	-	-	-	-	-	16	-
23.	Testing equipment and materials	-	-	-	-	-	-	-	1,440	-	-	-	-	1	1	-
24.	Spare parts I	-	-	-	-	-	-	-	2,390	-	-	-	-	1	-	-
25.	II	-	-	-	-	-	-	-	4,790	-	-	-	-	2	-	-
26.	III	-	-	-	-	-	-	-	3,360	-	-	-	-	2	-	-
	Stores - Totals															
27.	All processes (rows 21 to 23 + 24) I	-	-	-	-	-	-	-	33,400	-	-	-	-	2	19	-
28.	All processes (rows 21 to 23 + 25) II	-	-	-	-	-	-	-	35,800	-	-	-	-	3	19	-
29.	Syruping and bottling (rows 21 to 23 + 26) III	-	-	-	-	-	-	-	34,400	-	-	-	-	3	19	-
	Total Labour Force															
	Excluding transport															
30.	All processes I	-	-	-	-	-	-	-	-	-	-	2	6	11	78	16
31.	II	-	-	-	-	-	-	-	-	-	-	2	6	12	78	16
32.	Syruping and bottling III	-	-	-	-	-	-	-	-	-	-	1	2	11	27	8

Sources.
See text pages 22-24

Footnotes

(1) Capacity or size only.
... Figures not available.
- Nil, negligible or not applicable.
---- Sub-total or alternative total.
The values quoted in this table have been rounded to three significant figures.

Table 8

Factory Floorspace and Site Area. Initial Cost of Building and Annual Cost of Repairs. Annual Rent of Land

Values in Sterling: mid-1967

		Total Building Area sq. ft.	Total Site Area acres	Initial Cost of Buildings at £1.75 per sq. ft. Col. 6x1.75 £	Annual Cost of Repairs at £12 per 1,000 sq. ft. Col. 6x.012 £	Annual Cost of Rent at £100 per acre Col. cx100 £	Estimated Costs at Local Prices(1)		
							Buildings	Repairs	Rent
	a	b	c	d	e	f	g	h	i
	Scale A								
1	I Oranges	860	0.039	1,500	10	4	----	----	----
2	II Oranges and Compound	860	0.039	1,500	10	4	----	----	----
3	III Compound	570	0.026	997	7	3	----	----	----
	Scale B								
4	I Oranges	1,590	0.073	2,780	19	7	----	----	----
5	II Oranges and Compound	1,590	0.073	2,780	19	7	----	----	----
6	III Compound	1,130	0.052	1,980	14	5	----	----	----
	Scale C								
7	I Oranges	2,970	0.136	5,200	36	14	----	----	----
8	II Oranges and Compound	2,970	0.136	5,200	36	14	----	----	----
9	III Compound	2,060	0.095	3,600	25	9	----	----	----
	Scale D								
10	I Oranges	5,760	0.264	10,100	69	26	----	----	----
11	II Oranges and Compound	5,760	0.264	10,100	69	26	----	----	----
12	III Compound	3,940	0.181	6,900	47	18	----	----	----

Sources

Cols. b and c: Table 21. Site areas are assumed to be twice the building area. Prices are from local sources.
See text pages 24-25

Footnotes

(1) Spaces in this and some of the subsequent tables are for the reader's use.

The values quoted in this table have been rounded to three significant figures.

Table 9

Quantities and Costs of Materials per Shift for Squash made from Fresh Orange Juice (Scale A. 300 x 26.2/3 oz. bottles per Running Hour)

Values in Sterling: mid-1967

	Ingredients for Squash, 25 per cent juice 45° Brix (1) 1.5 per cent acidity		Quantity required per shift of 6.4 running hours	Price per unit: f.o.b. U.K. port Shillings	Price per unit: Delivered at factory Shillings	Cost per shift Col. $\frac{c \times e}{20}$ £	Estimated Local Costs: Local price	Estimated Local Costs: Local cost per shift Col. cxg	Estimated Local Costs: Annual cost at required output(3)
	a	b	c	d	e	f	g	h	i
1	Juice, 10° Brix 0.8% acidity	lb.	960.00	-	-	-	-	-	-
2	Sugar	lb.	1,580.00	...	0.625	49.40	----	----	----
3	Citric Acid	lb.	49.80	2.33	3.270	8.15	----	----	----
4	Orange Extract N.R.S.	gal.	2.00	90.00	146.000	14.60	----	----	----
5	Water	gal.	122.40	---	4.000 (per thousand gal.)	0.02	----	----	----
6	Orange Colour	lb.	0.50	12.20	17.200	0.43	----	----	----
7	Preservative, potassium metabisulphite	lb.	2.40	...	2.680	0.32	----	----	----
8	Totals excluding orange costs	gal. lb.	320.00 3,840.00	-	-	72.80	----	----	----
9	Oranges, net	lb.	2,400.00	-	-				
10	including 4% wastage)	tons	1.12	-	110.000(2)	6.14	----	----	----
11	Totals including orange costs	-	-	-	-	79.00	----	----	----

Sources

Col. c. Ref. 11.

Cols. d and e. British manufacturers and local sources.

See text page 25

Footnotes

(1) The Brix scale denotes the percentage by weight of sugar in a solution. The 45 per cent of sugar included 2.5 per cent provided by the fresh orange juice.
(2) Price paid to growers.
(3) Col. h multiplied by numbers of shifts worked per year, multiplied by scale factor, e.g. 2 for 600 bottles per hour or 8 for 2,400 bottles per hour.
- Nil, negligible or not applicable.
... Figures not available. --- Subtotal.

The values quoted in this table have been rounded to three significant figures.

Table 10

Quantities and Costs of Materials Per Shift for Squash made from Orange Compound.
(Scale A, 300 x 26.2/3 oz. bottles per Running Hour)

Values in Sterling: mid-1967

	Ingredients	Units	Quantities required per shift of 6.4 running hours	Price per unit		Cost per shift col. $\frac{c \times e}{20}$	Estimated local costs		
				f.o.b. U.K. port	delivered at factory		Local price	Local cost per shift col. cxg	Annual cost at required output(1)
				Shillings	Shillings	£			
	a	b	c	d	e	f	g	h	i
1	Ten-fold orange squash compound	gal.	32.0	27.5	45.000	72.10	----	----	----
2	9 per cent solution of sulphur dioxide	gal.	1.0	...	4.000	0.20	----	----	----
3	Sugar	lb.	1,730.0	...	0.625	54.10	----	----	----
4	Water	gal.	179.0	-	4.000	0.04 (0.03576)(2)			
5	Total	gal.	320.0	-	-	126.00	----	----	----

Sources

Col. c, d and e. British manufacturer of compound.

See text page 26

Footnotes

(1) Col. h. multiplied by number of shifts worked per year, multiplied by scale factor (e.g. 2 for 600 bottles per hour, 8 for 2,400 bottles per hour).
(2) Unrounded.
- Nil, negligible or not applicable.
... Figures not available.
The values quoted in this table have been rounded to three significant figures

Table 11

Quantities and Costs of Supplies per Shift. (Scale A. 300 x 26.2/3 oz. bottles per Running Hour)

Values in Sterling: mid-1967

	Items	Description	Rate of usage	Quantity required per shift of 6.4 running hours	Price per unit: f.o.b. U.K. port (Shillings)	Price per unit: delivered at factory (Shillings)	Cost per shift (£)	Estimated Local Costs: Local price	Estimated Local Costs: Local cost per shift col. dxh	Estimated Local Costs: Annual cost at required output(2)
	a	b	c	d	e	f	g	h	i	j
1	Bottles	26.2/3 fluid oz. glass	10 per cent loss	192 1.1/3 gross	-	88.80(1) per gross	5.92	——	——	——
2	Containers	cardboard cartons	1 per 12 bottles	160	-	2.00 per carton	16.00	——	——	——
3	Closures	resealable crown caps	1 per bottle	1,920	2.75 per gross	5.95 per gross	3.97	——	——	——
4	Labels	size 3 x 4 in.	1 per bottle	1,920	-	30.00 per 1,000	2.88	——	——	——
5	Sub-total rows 2 to 4	-	-	-	-	-	22.85 ——	——	——	——

Sources

Column f. British manufacturers and local sources.

See text page 26

Footnotes

(1) The estimated total, cost per gross of bottles delivered is £8.039 (13.4d. per bottle). It is assumed that a deposit of 6d. per bottle is charged so that the replacement cost is 7.4d. per bottle or £4.440 per gross.

(2) Col. i. multiplied by number of shifts worked per year, multiplied by scale factor, e.g. 2 for 600 bottles per hour, or 8 for 2,400 bottles per hour.

\- Nil, negligible or not applicable.

—— Subtotal.

The values quoted in this table have been rounded to three significant figures.

Table 12
Quantities and Costs of Electric Power

Values in Sterling: mid 1967

			Number of shifts worked	Estimated Units per shift	Demand charge per month of 20 shifts	Total demand charge col. $\frac{bxd}{20}$	Cost at 3d. per unit col. $\frac{bxcx3}{240}$	Annual cost col. e+f	Average cost per unit col. $\frac{gx240}{b \times c}$
				Kw. h.	£	£	£	£	pence
		a	b	c	d	e	f	g	h
		Scale A							
1	I	Oranges	80	19.00	6.75	27.0	19.0	46.0	7.27
2	II	Oranges	80	19.00	6.75	27.0	19.0	46.0	7.27
3		Compound	160	6.59	2.25	18.0	13.2	31.2	7.10
4		Total	240	-	-	45.0	32.2	77.2	7.20(1)
5	III	Compound	240	6.59	2.25	27.0	19.8	46.8	7.10
		Scale B							
6	I	Oranges	80	24.80	6.00	24.0	24.8	48.8	5.91
7	II	Oranges	80	24.80	6.00	24.0	24.8	48.8	5.91
8		Compound	160	7.40	2.25	18.0	14.8	32.8	6.65
9		Total	240	-	-	42.0	39.6	81.6	6.18(1)
10	III	Compound	240	7.40	2.25	27.0	22.2	49.2	6.65
		Scale C							
11	I	Oranges	80	78.60	21.30	85.2	78.6	164.0	6.25
12	II	Oranges	80	78.60	21.30	85.2	78.6	164.0	6.25
13		Compound	160	42.40	12.00	96.0	84.9	181.0	6.39
14		Total	240	-	-	181.0	163.0	345.0	6.33(1)
15	III	Compound	240	42.40	12.00	144.0	127.0	271.0	6.39
		Scale D							
16	I	Oranges	80	217.00	51.90	208.0	217.0	425.0	5.89
17	II	Oranges	80	217.00	51.90	208.0	217.0	425.0	5.89
18		Compound	160	154.00	36.20	290.0	307.0	597.0	5.83
19		Total	240	-	-	498.0	524.0	1,020.0	5.85(1)
20	III	Compound	240	154.00	36.20	435.0	460.0	896.0	5.83
		Estimated local costs							

Sources

Col. c derived from col. j of Tables 2 to 5.
Monthly demand and unit charges from local source.

See text pages 26-27

Footnotes

(1) Averaged over the year.
\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 13

Quantities and Costs of Wood Fuel for Boilers

Values in Sterling: mid-1967

		Number of shifts worked	Heat required per shift '000 BTUs	Wood required per shift cu. ft.	Wood required per period col. bxd cu. ft.	Annual cost at 6d. per cu. ft. col. $\frac{ex6}{240}$ £	Estimated Local Costs: Wood required per period if different from col. e	Estimated Local Costs: Local price per unit	Estimated Local Costs: Annual cost at required output col. e or gxh
	a	b	c	d	e	f	g	h	i
	Scales A and B								
1	I Oranges	80	3,810	26.0	2,080	52.0			
2	II Oranges	80	3,810	26.0	2,080	-			
3	Compound	160	443	3.0	480	-			
4	Total	240	-	-	2,560	64.0			
5	III Compound	240	443	3.0	720	18.0			
	Scale C								
6	I Oranges	80	7,360	50.2	4,020	100.0			
7	II Oranges	80	7,360	50.2	4,020	-			
8	Compound	160	862	5.9	944	-			
9	Total	240	-	-	4,960	124.0			
10	III Compound	240	862	5.9	1,420	35.4			
	Scale D								
11	I Oranges	80	12,000	81.5	6,520	163.0			
12	II Oranges	80	12,000	81.5	6,520	-			
13	Compound	160	2,460	16.8	2,690	-			
14	Total	240	-	-	9,210	230.0			
15	III Compound	240	2,460	16.8	4,030	101.0			

Sources

Col. c Computed from rows 19 and 21 of Table 22. Boilers are assumed to run for 8 hours per shift at an efficiency of 65 per cent.

Col. d The wood is assumed to have a calorific value of 5,500 BTU's per lb., and to weigh 26.67 lb. per cubic foot.

See text pages 27-28

Footnotes

(1) Figures in col. b were used unrounded.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 14
Quantities and Costs of Water for Processing

Values in Sterling: mid-1967

		Number of shifts worked	Water required per shift	Water required per period (stated in col. b)	Annual cost at 4s. per thousand gal. col. $\frac{dx4}{20}$	Estimated Local Costs: Water required per period (if different from col. d)	Local price per unit	Annual cost at required output col. e or fxh
			gal.	'000 gal.	£			
	a	b	c	d	e	f	g	h
	Scale A							
1	I Oranges	80	3,140	251	50.2			
2	II Oranges	80	3,140	251	-			
3	Compound	160	1,000	161	-			
4	Total	240	-	412	82.4			
5	III Compound	240	1,000	241	48.2			
	Scale B							
6	I Oranges	80	3,650	292	58.4			
7	II Oranges	80	3,650	292	-			
8	Compound	160	1,530	245	-			
9	Total	240	-	537	107.0			
10	III Compound	240	1,530	367	73.4			
	Scale C							
11	I Oranges	80	3,750	300	60.0			
12	II Oranges	80	3,750	300	-			
13	Compound	160	1,780	285	-			
14	Total	240	-	585	117.0			
15	III Compound	240	1,780	427	85.4			
	Scale D							
16	I Oranges	80	5,440	435	87.0			
17	II Oranges	80	5,440	435	-			
18	Compound	160	3,320	531	-			
19	Total	240	-	966	193.0			
20	III Compound	240	3,320	797	159.0			

Sources
Cols. c and d Table 22.
Col. d Price from local source.
See text page 28

Footnotes
- Nil, negligible or not applicable.
The values quoted in this table have been rounded to three significant figures.

Table 15

Transport for Orange Collection Squash Distribution and Collection of Empty Bottles. Annual Cost of Hired Transport

Values in Sterling: mid-1967

		Operating periods		Loads per shift to be moved(1)		Average length of trip		Number of depots visited once a week(2)	Vehicle days required per year cols. cxgxh	Lorries required (each capable of 210 vehicle days)(3)		Distance covered per period shown in col. c.(3) col. cxfxh miles	Estimated annual cost of hired transport at 8d. per ton mile(4)	
		Shifts per week	Weeks per year	Tons	Number of loads	Miles	Vehicle days			Capacity tons	Number		Ton-miles col. bxcxdxf / 2	Cost £
	a	b	c	d	e	f	g	h	i	j	k	l	m	n
	Scale A, 300 bottles per running hour													
1	Orange collection I and II	5	16	1.12	½	26.5	¼	5	20	3.3	1	2,120	1,190	39.6
2	Squash distribution I	5	16	2.86	1	70.0	½	5	40	-	-	5,600	8,010	266.0
3	Squash distribution II and III	5	48	2.86	1	70.0	½	5	120	3.3	1	16,800	24,000	801.0
	Scale B, 600 bottles per running hour													
4	Orange collection I and II	5	16	2.23	1	26.5	¼	10	40	3.3	1	4,240	2,360	78.8
5	Squash distribution I	5	16	5.72	2	70.0	½	10	180	3.3	1	11,200	16,000	534.0
6	Squash distribution II and III	5	48	5.72	2	70.0	½	10	240	3.3	2	33,600	48,000	1,600.0
	Scale C, 1,200 bottles per running hour													
7	Orange collection I and II	5	16	4.46	2	26.5	¼	10	40	3.3	1	4,240	4,730	158.0
8	Squash distribution I	5	16	11.40	2	70.0	½	10	80	6.8	1	11,200	32,000	1,070.0
9	Squash distribution II and III	5	48	11.40	2	70.0	½	10	240	6.8	2	33,600	96,100	3,200.0
	Scale D, 2,400 bottles per running hour													
10	Orange collection I and II	5	16	8.93	2	26.5	¼	20	80	3.3	1	8,480	9,470	316.0
11	Squash distribution I	5	16	22.90	4	70.0	½	20	160	6.8	2	22,400	64,100	2,140.0
12	Squash distribution II and III	5	48	22.90	4	70.0	½	20	480	6.8	3	67,200	192,000	6,410.0

Sources

See text pages 28-31

The values quoted in this table have been rounded to three significant figures.

Footnotes

(1) Empty bottles are assumed to be collected on return journeys.

(2) In cases B and D the same quantity of oranges is collected from twice the number of depots assumed in cases A and C respectively. In case C twice the quantity of oranges is collected from the same number of depots, as in B.

(3) There is some reason to think that the figures in these columns are under estimates. See text page 28).

(4) Transport is assumed to be hired for collection of ranges only in cases B, C and D. In all other cases, the firm's own transport is assumed to be used. Only the cost of squash distribution is estimated in col. m. The cost of bringing in empties on the return journey would be additional.

\- Nil, negligible or not applicable.

Table 16

Cost of Owned Transport

Values in Sterling: mid-1967

	Case AI	a	Case AII	b	Case AIII	c
1	1 lorry capacity, tons	3.3	1 lorry capacity, tons	3.3	1 lorry capacity, tons	3.3
2	miles per gal.	10	miles per gal.	10	miles per gal	10
3	local price	£1,870(1)	local price	£1,870	local price	£1,870
4	Total annual mileage	7,720	Total annual mileage	18,900	Total annual mileage	16,800
	Annual costs of 1 lorry	£	Annual costs of 1 lorry	£	Annual costs of 1 lorry	£
5	Depreciation, 4 year life	468	Depreciation, 3 year life	623	Depreciation, 3 year life	623
6	Licence and insurance	(100)	Licence and insurance	(100)	Licence and insurance	(100)
7	Wages of driver and mate	240	Wages of driver and mate	240	Wages of driver and mate	240
8	Annual maintenance	(50)	Annual maintenance	(50)	Annual maintenance	(50)
9	Tyres, ½ set	(50)	Tyres, 1 set	(100)	Tyres, 1 set	(100)
10	Fuel at 4s. per gal	154	Fuel at 4s. per gal.	378	Fuel at 4s. per gal.	336
11	Total cost. 1 lorry	1,062	Total cost. 1 lorry	1,490	Total cost. 1 lorry	1,450
12	Average cost per mile	2s. 9d.	Average cost per mile	1s. 7d.	Average cost per mile	1s. 8¾d.

	Case BI	a	Case BII	b	Case BIII	c
13	1 lorry capacity, tons	3.3	2 lorries capacity, tons	3.3	2 lorries capacity, tons	3.3
14	miles per gal.	10	miles per gal.	10	miles per gal.	10
15	local price	£1,870	local price	£1,870	local price	£1,870
16	Total annual mileage	11,200	Total annual mileage	37,800	Total annual mileage	33,600
	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£
17	Depreciation, 4 year life	468	Depreciation, 3 year life	623	Depreciation, 3 year life	623
18	Licence and insurance	(100)	Licence and insurance	(100)	Licence and insurance	(100)
19	Wages of driver and mate	240	Wages of driver and mate	240	Wages of driver and mate	240
20	Annual maintenance	50	Annual maintenance	(50)	Annual maintenance	(50)
21	Tyres, ½ set	50	Tyres, 1 set	(100)	Tyres, 1 set	(100)
22	Fuel at 4s. per gal.	224	Fuel at 4s. per gal.	378	Fuel at 4s. per gal.	336
23	Total cost. 1 lorry	1,132	Total cost. 1 lorry	1,490	Total cost. 1 lorry	1,450
24			2 lorries	2,980	2 lorries	2,900
25	Average cost per mile	2s. 4¼d.	Average cost per mile	1s. 7d.	Average cost per mile	1s.10¾d.

	Case CI	a	Case CII	b	Case CIII	c
26	1 lorry capacity, tons	6.8	2 lorries capacity, tons	6.8	2 lorries capacity, tons	6.8
27	miles per gal.	8.5	miles per gal.	8.5	miles per gal.	8.5
28	local price	£2,600	local price	£2,600	local price	£2,600
29	Total annual mileage	11,200	Total annual mileage	37,800	Total annual mileage	33,600
	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£
30	Depreciation, 4 year life	649	Depreciation, 3 year life	865	Depreciation, 3 year life	865
31	Licence and insurance	200	Licence and insurance	200	Licence and insurance	200
32	Wages of driver and mate	240	Wages of driver and mate	240	Wages of driver and mate	240
33	Annual maintenance	100	Annual maintenance	100	Annual maintenance	100
34	Tyres, ½ set	87.5	Tyres, 1 set	175	Tyres, 1 set	175
35	Fuel at 4s. per gal.	264	Fuel at 4s. per gal.	445	Fuel at 4s. per gal.	395
36	Total cost. 1 lorry	1,540	Total cost. 1 lorry	2,025	Total cost. 1 lorry	1,980
			2 lorries	4,050	2 lorries	3,950
37	Average cost per mile	2s. 9d.	Average cost per mile	2s. 1¾d.	Average cost per mile	2s. 4¼d.

	Case DI	a	Case DII	b	Case DIII	c
38	2 lorries capacity, tons	6.8	3 lorries capacity, tons	6.8	3 lorries capacity, tons	6.8
39	miles per gal.	8.5	miles per gal.	8.5	miles per gal.	8.5
40	local price	£2,600	local price	£2,600	local price	£2,600
41	Total annual mileage	22,400	Total annual mileage	75,700	Total annual mileage	67,200
	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£	Annual cost of 1 lorry	£
42	Depreciation, 4 year life	649	Depreciation, 3 year life	865	Depreciation, 3 year life	865
43	Licence and insurance	200	Licence and insurance	200	Licence and insurance	200
44	Wages of driver and mate	240	Wages of driver and mate	240	Wages of driver and mate	240
45	Annual maintenance	100	Annual maintanance	100	Annual maintenance	100
46	Tyres, ½ set	175	Tyres, 2 sets	250	Tyres, 1 set	175
47	Fuel at 4s. per gal.	263	Fuel at 4s. per gal.	594	Fuel at 4s. per gal.	527
48	Total cost. 1 lorry	1,630	Total cost. 1 lorry	2,350	Total cost. 1 lorry	2,110
49	2 lorries	3,250	3 lorries	7,050	3 lorries	6,320
50	Average cost per mile	2s.10¾d.	Average cost per mile	1s.10¼d.	Average cost per mile	1s.10½d.

Sources
Suppliers of lorries.
Mileages from col. 1 of Table 15.
See text page 31

(1) Local prices of lorries include the cost of wooden bodies.
( ) estimate.
The values quoted in this table have been rounded to three significant figures.

Table 17

Scale A. Complements and Costs for Management, Supervision and Labour

Values in Sterling: mid-1967

	Type of Employee	Status	Costs per shift, including social security payments	I 80 Shifts: oranges				II 80 Shifts: oranges; 160 Shifts: compound				III 240 Shifts: compound			
				Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{cxd}{20}$	Cost per year(1) col. exf	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{cxh}{20}$	Cost per year(1) col. ixj	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{cxl}{20}$	Cost per year(1) col. mxn
			Shillings			£	£			£	£			£	£
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1	Managerial	permanent	119.00	1	240	5.95	1,428.0	1	240	5.95	1,430.0	1	240	5.95	1,430
2	Supervisory	permanent	21.50	2	240	2.15	517.0	2	240	2.15	517.0	1	240	1.07	258
3	Subtotal	permanent	-	-	-	8.10	1,945.0	-	-	8.10	1,940.0	-	-	7.02	1,690
4	Semi-skilled	permanent	10.50	3	240	1.58	378.0	3	240	1.58	378.0	2	240	1.05	252
5		temporary	10.50	-	-	-	-	-	-	-	-	-	-	-	-
6	Non-skilled	permanent	5.04	-	-	-	-	1.6	240	4.03	968.0	16	240	4.03	968
7		temporary	5.04	24	80	6.05	484.0	8	80	2.02	161.0	-	-		
8	Clerical	permanent	8.40	-	-	-	-	1	240	0.42	101.0	1	240	0.42	101
9		temporary	8.40	2	80	0.84	67.2	1	80	0.42	33.6	-	-	-	-
10	Subtotal	permanent and temporary	-	-	-	8.47	929.0	-	-	8.47	1,641.0	-	-	5.50	1,320

Sources

Columns d, h and l. Tables 4 to 7.

Columns f, j and n. Questionnaire.

See text page 31 and 32

Footnotes

(1) Annual costs are calculated from unrounded figures.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 18

Scale B. Complements and Costs for Management, Supervision and Labour

Values in Sterling: mid-1967

	Type of Employee	Status	Costs per shift, including social security payments	Scale B. 600 bottles per running hour											
				I 80 Shifts: oranges				II 80 Shifts: oranges 160 Shifts: compound				III 240 Shifts: compound			
				Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times d}{20}$	Cost per year(1) col. exf	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times h}{20}$	Cost per year(1) col. ixj	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times l}{20}$	Cost per year(1) col. mxn
			Shillings			£	£			£	£			£	£
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1	Managerial	permanent	119.00	1	240	5.95	1,430	1	240	5.95	1,430	1	240	5.95	1,430
2	Supervisory	permanent	21.50	2	240	2.15	517	2	240	2.15	517	1	240	1.07	258
3	Subtotal	permanent	-	-	-	8.10	1,940	-	-	8.10	1,940	-	-	7.02	1,690
4	Semi-skilled	permanent	10.50	3	240	1.58	378	4	240	2.10	504.0	3	240	1.58	378
5		temporary	10.50	-	-	-	-	-	-	-	-	-	-	-	-
6	Non-skilled	permanent	5.04	-	-	-	-	32	240	8.06	1,935.0	32	240	8.06	1,940
7		temporary	5.04	47	80	11.80	948	15	80	3.78	302.0	-	-	-	-
8	Clerical	permanent	8.40	-	-	-	-	2	240	0.84	202.0	2	240	0.84	202
9		temporary	8.40	4	80	1.68	134	2	80	0.84	67.2	-	-	-	-
10	Subtotal	permanent and temporary	-	-	-	15.10	1,460	-	-	15.60	3,010.0	-	-	10.50	2,520

Sources

Columns d, h and l. Tables 4 to 7.

Columns f, j and n. Questionnaire.

See text page 31-32

Footnotes

(1) Annual costs are calculated from unrounded figures.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 19

Scale C. Complements and Costs for Management, Supervision and Labour

Values in Sterling: mid-1967

	Type of Employee	Status	Costs per shift, including social security payments	Scale C. 1,200 bottles per running hour											
				I 80 Shifts: oranges				II 80 Shifts: oranges 160 Shifts: compound				III 240 Shifts: compound			
				Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times d}{20}$	Cost per year(1) col. exf	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times h}{20}$	Cost per year(1) col. ixj	Employees of each type and status	Shifts paid for per year	Cost per shift col. $\frac{c \times l}{20}$	Cost per year(1) col. mxn
			Shillings			£	£			£	£			£	£
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1	Managerial	permanent	119.00	1	240	5.95	1,430	1	240	5.95	1,430	1	240	5.95	1,430
2	Supervisory	permanent	21.50	4	240	4.30	1,030	4	240	4.30	1,030	2	240	2.15	517
3	Subtotal	permanent	-	-	-	10.20	2,460	-	-	10.20	2,460	-	-	8.10	1,940
4	Semi-skilled	permanent	10.50	5	240	2.63	631	6	240	3.15	756	5	240	2.63	631
5		temporary	10.50	-	-			-	-			-	-		
6	Non-skilled	permanent	5.04	-				40	240	10.10	2,420	40	240	10.10	2,420
7		temporary	5.04	65	80	16.40	1,310	25	80	6.30	504				
8	Clerical	permanent	8.40	4	240	1.68	403	4	240	1.68	403	4	240	1.68	403
9		temporary	8.40	4	80	1.68	134	4	80	1.68	134	-	-		
10	Subtotal	permanent and temporary	-	-	-	22.40	2,480	-	-	22.90	4,220	-	-	14.40	3,450

Sources

Columns d, h and l. Tables 4 to 7.

Columns f, j and n. Questionnaire.

See text page 31-32

Footnotes

(1) Annual costs are calculated from unrounded figures.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 20

Scale D. Complements and Costs for Management, Supervision and Labour

Values in Sterling: mid-1967

	Type of Employee	Status	Costs per shift, including social security payments	Scale D. 2,400 bottles per running hour											
				I 80 Shifts: oranges				II 80 Shifts: oranges 160 Shifts: compound				III 240 Shifts: compound			
				Employees of each type and status	Shifts paid for per year	Cost per shift col. cxd/20	Cost per year (1) col. exf	Employees of each type and status	Shifts paid for per year	Cost per shift col. cxh/20	Cost per year(1) col. ixj	Employees of each type and status	Shifts paid for per year	Cost per shift col. cxl/20	Cost per year(1) col. mxn
			Shillings			£	£								
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1	Managerial	permanent	119.00	2	240	11.90	2,860	2	240	11.90	2,860	1	240	5.95	1,428
2	Supervisory	permanent	21.50	6	240	6.46	1,550	6	240	6.46	1,550	2	240	2.15	517
3	Subtotal	permanent	-	-	-	18.36	4,410	-	-	18.40	4,410	-	-	8.10	1,940
4	Semi-skilled	permanent	10.50	11	240	5.78	1,390	12	240	6.30	1,510	11	240	5.78	1,390
5		temporary	10.50	-	-			-	-			-	-		
6	Non-skilled	permanent	5.04	-				27	240	6.80	1,630	27	240	6.80	1,630
7		temporary	5.04	78	80	19.66	1,570	51	80	12.90	1,030	-	-		
8	Clerical	permanent	8.40	8	240	3.36	806	8	240	3.36	806	8	240	3.36	806
9		temporary	8.40	8	80	3.36	269	8	80	3.36	269	-	-		
10	Subtotal	permanent and temporary	-	-	-	32.16	4,030	-	-	32.70	5,250	-	-	15.90	3,820

Sources

Columns d, h and l. Tables 4 to 7.

Columns f, j and n. Questionnaire.

See next page 31-32

Footnotes

(1) Annual costs are calculated from unrounded figures.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.

Table 21

Floorspace for Storage and Processing, Site Area

	Description of area	Units	Scale A 300 bottles per running hour		Scale B 600 bottles per running hour		Scale C 1,200 bottles per running hour		Scale D 2,400 bottles per running hour	
			I and II	III	I and II	III	I and II	III	I and II	III
	a	b	c	d	e	f	g	h	i	j
1	Fruit store	sq. ft.	80	-	160	-	320	-	640	-
2	Juice extraction and bottling	sq. ft.	350	-	570	-	930	-	1,680	-
3	Bottling only	sq. ft.	-	140	-	270	-	340	-	500
4	Empty bottle store	sq. ft.	230	230	460	460	920	920	1,840	1,840
5	Full bottle store	sq. ft.	200	200	400	400	800	800	1,600	1,600
6	Total building area	sq. ft.	860 ---	570 ---	1,590 -----	1,130 -----	2,970 -----	2,060 -----	5,760 -----	3,940 -----
7	Total site area (row 6 x 2)	sq. ft.	1,720	1,140	3,180	2,260	5,940	4,120	11,520	7,880
8	Total site area	acres	0.039	0.026	0.073	0.052	0.136	0.095	0.264	0.181

Sources

Rows 2 and 3. Derived by multiplying net floorspace. Totals from Tables 4-7 by 3 and rounding off.

Other rows. Sources are given in text. See text pages 24-25.

Footnotes

- Nil, negligible or not applicable.

--- Subtotal

The values quoted in this table have been rounded to three significant figures.

Table 22

Quantities of Water, Hot Water and Steam. Estimated Boiler Capacity

	Purpose for which water is required	Period of reference	Scale A 300 bottles per running hour		Scale B 600 bottles per running hour		Scale C 1,200 bottles per running hour		Scale D 2,400 bottles per running hour	
			gal.	temperature °F.	gal.	temperature °F.	gal.	temperature °F.	gal.	temperature °F.
	a	b	c	d	e	f	g	h	i	j
1	Squash made from oranges	1 hour	20	60	40	60	80	60	160	60
2	Squash made from compound	1 hour	28	60	56	60	112	60	224	60
3	Fruit washer, hot water	1 hour	100	160	100	160	25 (250 lb. steam)	-	25 (250 lb. steam)	-
4	Fruit washer, cold water	1 hour	150	60	150	60	200	60	200	60
5	Steam jacketed pans	1 hour	18 (174 lb. steam)	-	18 (174 lb. steam)	-	28 (278 lb. steam)	-	53 (521 lb. steam)	-
6	Bottle washer, hot water	1 hour	80	105	80	105	100	130	20	-
7	Bottle washer, cold water	1 hour	40	60	80-100	60	100	60	350	60
	<u>Total water required per hour a shift</u>									
8	All processes, I (row 1 + 3 + 4 + 5 + 6 + 7)	1 hour	408	-	488	-	533	-	808	-
9	Cleaning allowance (row 8 x 1.25)	1 hour	510	-	610	-	666	-	1,010	-
10	Requirements per shift (row 9 x 6.4)	6.4 hours	3,260	-	3,900	-	4,260	-	6,460	-
11	Same, less water used in squash (row 10 - [row 1 x 6.4])	6.4 hours	3,140	-	3,650	-	3,750	-	5,440	-
12	Bottling only III (row 2 + 6 + 7)	1 hour	148	-	236	-	312	-	594	-
13	Cleaning allowance (row 12 x 1.25)	1 hour	185	-	295	-	390	-	742	-
14	Requirements per shift (row 13 x 6.4)	6.4 hours	1,180	-	1,890	-	2,500	-	4,750	-
15	Same, less water used in squash (row 14 - [row 2 x 6.4])	6.4 hours	1,000	-	1,530	-	1,980	-	3,320	-
	<u>Estimated BTU's required</u>		B Th U's		B Th U's		B Th U's		B Th U's	
16	Fruit washer	1 hour	100,000	-	100,000	-	250,000	-	250,000	-
17	Steam jacketed pan	1 hour	174,000	-	174,000	-	278,000	-	521,000	-
18	Bottle washer	1 hour	36,000	-	36,000	-	70,000	-	200,000	-
	<u>Total BTU's required</u>									
19	Including juice processing, I and II (row 22 + 23 + 24) (16 + 17 + 18)	1 hour	310,000	-	310,000	-	598,000	-	971,000	-
20	Approximate boiler capacity(1) (row 19 x 1.1/3)	1 hour	413,000	-	413,000	-	798,000	-	1,300,000	-
21	Bottling only, III (row 18)	1 hour	36,000	-	36,000	-	70,000	-	200,000	-
22	Approximate boiler capacity (row 21 x 1.1/3)	1 hour	93,000(2)	-	93,000(2)	-	141,000(2)	-	267,000	-

Sources

<u>Rows 1 and 2.</u> Computed from Tables 4 to 7.

<u>Rows 3, 4 and 7.</u> Given by machinery makers.

<u>Row 5.</u> Amount of water converted to steam required to produce B Th U's shown in row 17.

<u>Rows 16 to 18.</u> Computed by multiplying the weight in lb. of water required per hour by the difference between the required temperature and 60°F. or by multiplying the number of lb. of steam required by 1,000 to yield B Th U's. [illegible] c, e and g are catalogue ratings

Footnotes

(1) One third must be added to the estimated B Th U's required to allow for the fact that a larger fuel compartment is required for wood than for coal.

(2) See source note on row 22.

\- Nil, negligible or not applicable.

The values quoted in this table have been rounded to three significant figures.